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ADVERTISING OFFICES
E. L. Carroll
Eastern Advertising Manager
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CREATIVE ENGINEERING

GEARED TO QUANTITY PRODUCTION

ANNOUNCES THE *New*

BENDIX HAND CONTROL VALVE

Finer Performance At A Lower Cost Than Ever Before!

Here is the valve that gives truckers the ultimate in hand controls for vacuum braking systems—but *costs even less* than ordinary models. The new Bendix Hand Control Valve is a simple, rugged unit with a clean, modern appearance that adds to the good looks of any cab interior. Its absolute dependability and consistent precision set an all time high for performance—and at a lower cost than ever before! Available with or without an integral, easy-to-read vacuum gauge, the new Bendix Hand Control Valve assures maximum flexibility with today's vacuum trailer braking assemblies. For complete details write the factory direct.

BENDIX · PRODUCTS DIVISION · SOUTH BEND

AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York

GRADUATES ACCURATELY

The new Bendix Hand Control Valve applies the brakes in amount exactly corresponding to where the handle is set—no more and no less—and the driver can depend on it.

ACTS CONSISTENTLY

Graduated braking is always the same, in application and release each time the valve is used.

BUILDERS OF THE BASICS OF BETTER MOTOR VEHICLES

HOLDS A SETTING

When the handle is left in a fixed position, there is no tendency for brakes to creep on or off—no "leakover" when the valve is seated.

AND HERE'S WHY

This new hand control valve is a product of Bendix, greatest name in braking. Engineered and precision built, it delivers dependable performance under all operating conditions.

Engineers Aim For ECONOMY & SAFETY

CLEAR demonstration of the varied engineering skills combined in motor car design and manufacture came out of the SAE National Passenger Car, Body, and Production Meeting in Detroit, March 14-16. Spontaneous discussion and planned presentation showed how specialists in numerous fields work toward producing a less costly, more comfortable car for the driver, safety in design from the pedestrian's standpoint, and toward preventing waste-disposal troubles in the plant community.

The meeting was sponsored by the Passenger, Production, Body, and Engineering Materials Activities. General Committee Chairman P. H. Pretz coordinated planning and operation of this highly successful meeting. On behalf of the Production Activity, Joseph Geschelin organized the Production Clinic panels.

Clinic Big Attraction

Standing-room-only crowds attending the eight all-day panels of the Production Clinic yielded a fund of practical knowledge for manufacturing men. From queries and advice, agreements and disagreements on all phases of production emerged patterns for better ways to use manufacturing facilities and to fabricate automotive products. (*On-the-spot reports of this free interchange of ideas will be published in the May issue of the SAE Journal.*)

Del S. Harder, vice-president of manufacturing, Ford Motor Co., commended such pooling of knowledge by automotive men in his talk at the dinner, which closed the meeting. The dinner, toastmastered by Harvey Campbell, executive vice-president, Detroit Board of Commerce, was opened with a word of welcome from Detroit Section Chairman A. C. Hazard. SAE President James C. Zeder spoke briefly.

To engineers at the meeting, Harder said:

"Our jobs are bigger than we think, because our nation and the world seem imbued with the idea that master-minding can solve problems.

"This industry—and probably most American industries—can solve problems without government planning, as we have proved so convincingly both in time of war and of peace." Strength of industry, he continued, is in the exchange of know-how to increase production and improve quality, as demonstrated by the meeting participants.

Harder went on to say: "Economic progress is largely a job for engineers and production men. On our ability to produce more and more goods and services at lower and lower cost may rest the fate of private enterprise. That may sound like a tough assignment. But I'm confident that we, as individuals and as a group, can meet it successfully.

"To be specific about this job we have to do, I

Continued on Page 63

Dinner Speaker

Del S. Harder
vice-president of manufacturing, Ford Motor Co.

Which earthmover for the job . . . the one with more power, greater capacity, or higher speed? In this article Carroll shows how to approach the problem in terms of specific examples. He does this from these two standpoints:

(a) **Yardage Production** — number of cubic yards of material handled, and

(b) **Specific Costs**—cost per cubic yard of material moved.

Evaluating For

a. Yardage Production...

TRACTOR-SCRAPER UNITS	A REFERENCE	B HIGH HORSEPOWER	C HIGH CAPACITY	D HIGH TOP SPEED
HORSEPOWER	125	200	125	125
CAPACITY YARDS HEAPED	12	12	19.2	12
TOP SPEED M P H	25	25	25	40
EMPTY WEIGHT	38,100	41,100	46,950	38,600

RUBBER-TIRED TRACTOR-SCRAPER EXAMPLE UNITS		A REFERENCE	B HIGH H.P.	C HIGH CAPACITY	D HIGH TOP SPEED
CONDITION #1 75#/T R.R. 1¼% DOWNGRADE	LOADED SPEED	16.6	25.0	12.5	16.6
	EMPTY SPEED	16.2	23.6	13.3	16.2
	AVERAGE SPEED	16.4	24.3	12.9	16.4
CONDITION #2 75#/T R.R. 5% DOWNGRADE	LOADED SPEED	25.0	25.0	25.0	40.0
	EMPTY SPEED	9.8	14.6	5.8	9.8
	AVERAGE SPEED	14.1	18.4	9.4	15.8
CONDITION #3 75#/T R.R. 1¼% ADVERSE GRADE	LOADED SPEED	9.6	14.4	6.8	9.2
	EMPTY SPEED	25.0	25.0	21.8	28.0
	AVERAGE SPEED	13.9	18.3	10.4	13.9
CONDITION #4 75#/T R.R. 5% ADVERSE GRADE	LOADED SPEED	5.6	8.7	4.1	5.6
	EMPTY SPEED	25.0	25.0	25.0	40.0
	AVERAGE SPEED	9.2	12.9	7.1	9.8

1. Greatest yardage delivery and lowest yardage cost depends on a balance of power, capacity, and speed. Here we will study performance in terms of yardage production and costs of four rubber-tired tractor and scraper units, each operating under four sets of conditions.

The units are designated A, B, C, and D, as shown above. The A unit is the reference unit, with the horsepower, capacity, speed, and empty weight chosen to make its performance and characteristics comparable with existing popular machines. The comparative units are chosen so that the factors of increased horsepower, capacity, and top speed can be individually studied. Basic difference in the comparative units as contrasted with the reference unit are as follows:

- Unit B—60% increase in horsepower.
- Unit C—60% increase in capacity.
- Unit D—60% increase in top speed.

Although only one basic change is made on each unit, each change requires other modifications from an engineering standpoint. Weights, tire sizes, and machine costs must be adjusted accordingly. Consideration of these other changes were made in arriving at the production and cost figures.

2. This discussion is confined to rubber-tired tractor-scraper units assisted in loading by a pusher tractor. The 12-yd scrapers are loaded by a 12-ton tractor and the 19-yd scraper by a 17-ton tractor. Productivity of each scraper unit in cubic yards per hour is equal to the capacity of the pusher tractor (yards per hour) divided by the number of scrapers required for a given haul length.

The table above shows the haul, return, and average speeds of the four units, each under four different operating conditions. Each condition involves the same rolling resistance of 75 lb per ton.

Condition No. 1 was chosen to match the performance of the B unit. Note that unit B's top speed is about 25 mph on both the haul and the return. This speed coupled with vehicle drag demands full output of available horsepower. Incidentally, available horsepower in all cases is considered as 72.5% of the engine horsepower to compensate for transmission losses and only partial availability of power through a stepped transmission.

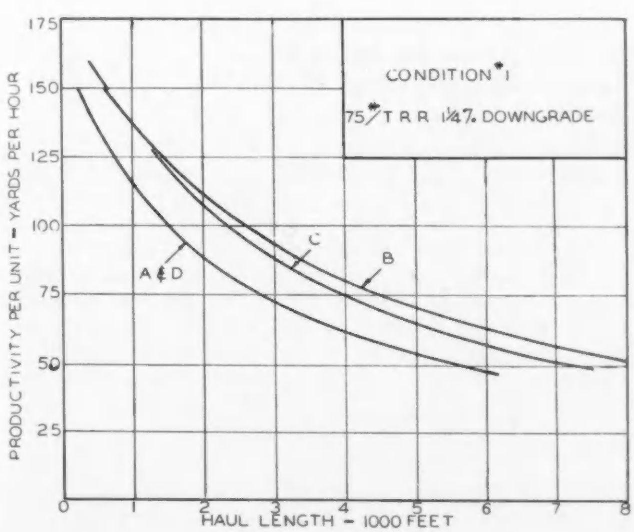
* Paper "Obtaining Higher Average Speeds by the Utilization of Horsepower in Earthmoving Equipment," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 13, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

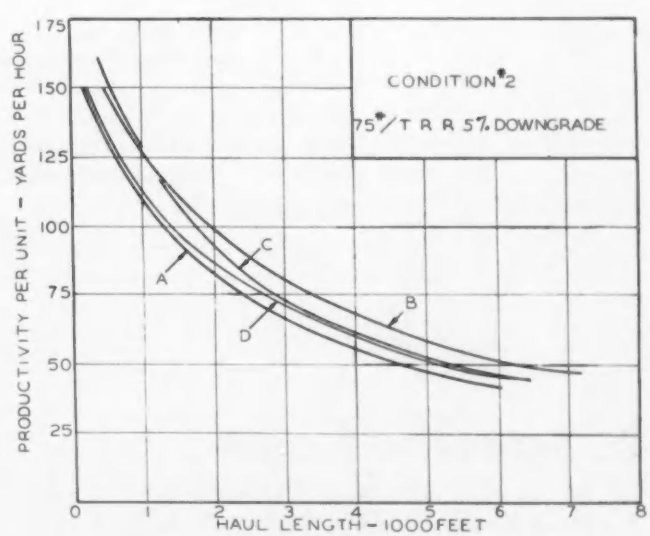
Earthmoving Machines Productivity & Costs

BASED ON PAPER* BY

John P. Carroll

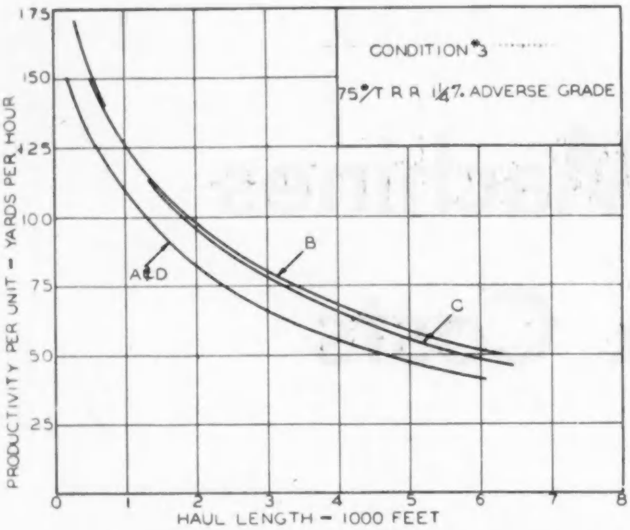
Supervising Engineer
Caterpillar Tractor Co.



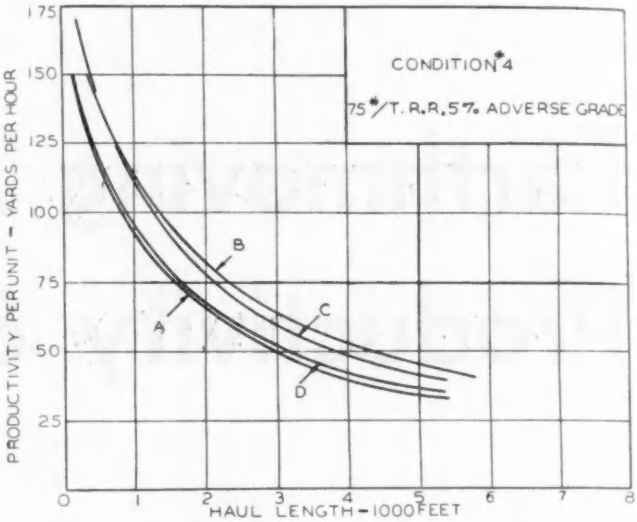


3. Under Condition No. 1, the C unit is the greatest producer up to 1000 ft, although it has the lowest average speed and highest fixed cycle time. The larger capacity favors this unit on short hauls. From 1000 ft, the B unit shows an increasing production advantage over the C unit. Here the high average speed favors this unit. The A and D units parallel each other under this condition, as the chart above shows, and yield less yardage production. Average speed for these units are nearly the same, since the high top speed of the D unit is not usable under this condition of slight downgrade haul.

4. On the 5% down grade, the B unit passes the C unit at 1100 ft and consistently remains in the lead with about 6 yd per hr margin. As the haul length increases, the D unit gradually approaches the C unit and equals production at 6500 ft. Higher top speed on the greater down-grade haul permits this unit to approach production of the high-horsepower and high-capacity units. The A unit produces very close to the C and D units because it works at its top speed on the haul and maintains a reasonable speed on the return trip, due to its lighter weight and use of its available horsepower.



5. On the 1¼% adverse grade the relationship between the B and C units is virtually the same as in the first condition; but the yardage production is lower due to the adverse haul grade. Average speeds and productivity are nearly the same as in Condition No. 2.



6. Yardage production is lowest of all on the 5% adverse grade. Production of B and C units still remains close, with the A and D units somewhat below. The A and D units show a lower average speed than B, but higher than C, which retains favorable production by virtue of its capacity.

For the conditions shown in Charts 3 to 6 inclusive, the high-horsepower and high-capacity units hold the advantage. Under conditions with a lower rolling resistance, the A unit would show up better comparatively, because of maximum use of available horsepower. In this case the high-horsepower unit would be wasting horsepower.

b. Specific Costs . . .

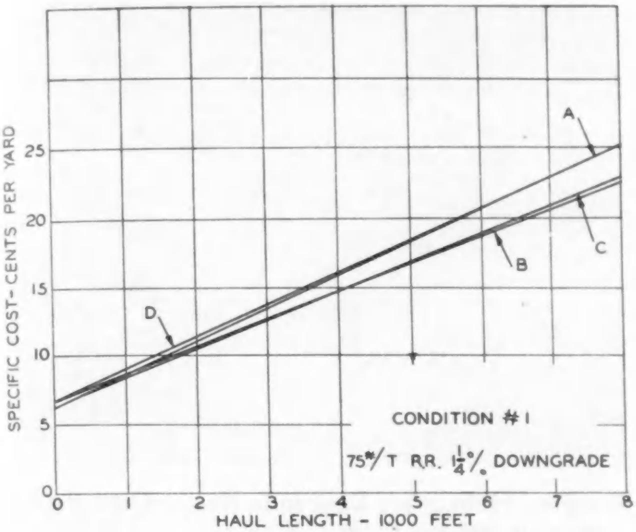
7. To get specific costs of material moved in cents per cubic yard for the four units, we first compute the hourly operating costs of each unit. The fixed costs are depreciation, interest, insurance, and taxes. The variable costs are fuel, oil, grease, repairs, and tires. To the fixed and variable costs we add the operator cost and get the total hourly operating cost of the unit, as shown in the table at right.

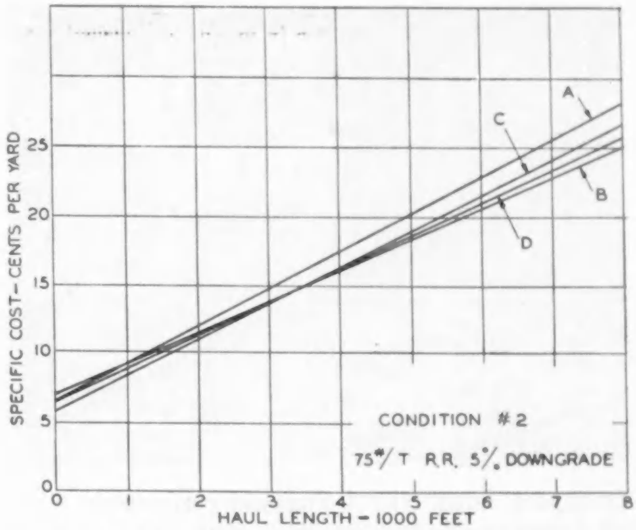
The hourly pusher cost must be computed to get the specific cost. The haul length determines the final specific cost; as the haul length increases, the number of units required to keep the pusher busy also increases. Final computation of specific cost in cents per yard is obtained from this formula:

$$\text{Specific Cost} = \frac{\text{No. of scrapers} \times \text{hourly cost}}{\text{Pusher production in yards}} + \text{Pusher cost in cents per yard}$$

The table below shows the total hourly operating and pusher cost. Relative specific costs of the four units operating under the given conditions are given in the charts on the following page.

TRACTOR-SCRAPER UNIT	A REFERENCE	B HIGH HORSEPOWER	C HIGH CAPACITY	D HIGH TOP SPEED
CONDITION #1 1¼% DOWNGRADE	8.84	10.99	10.02	9.02
CONDITION #2 5% DOWNGRADE	8.52	10.10	9.23	8.94
CONDITION #3 1¼% ADVERSE GRADE	8.49	10.08	9.44	8.69
CONDITION #4 5% ADVERSE GRADE	7.84	9.27	8.69	8.09
PUSHER COST	4.80	4.80	5.69	4.80



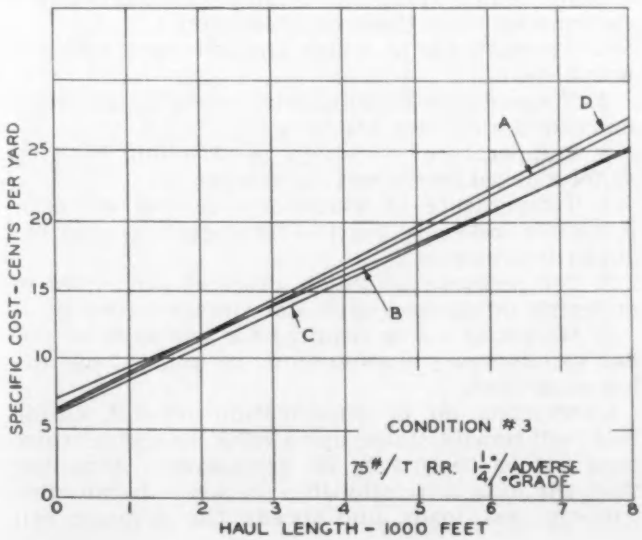


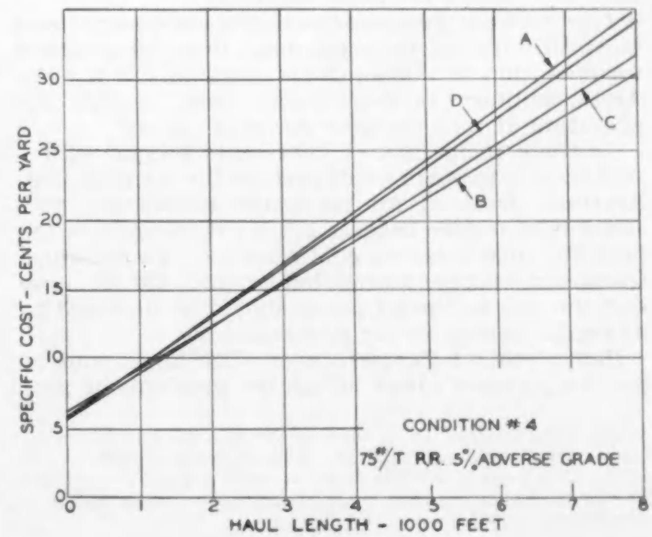
8. Specific costs are very close for all the given conditions on the shorter hauls. On this chart (for 1¼% down grade) the B and C units nearly parellel each other, with increasingly lower relative costs to the A and D units as the haul length increases. Although total hourly cost is the highest with unit B, higher average speed gives it a favorable comparison with C.

9. On the 5% down grade, in the chart above, the C unit shows the lowest cost up to 3500 ft, where the B and D units cross with an increasingly lower cost with haul length increase. The higher average speed of the D unit under this condition plus a low hourly cost gives it the edge over the C unit.

10. The A unit shows a lower cost than D on the 1¼% adverse grade because the average speed and resulting productivity are the same, and the hourly cost lower. Unit B shows highest cost on shorter hauls and matches the low cost of C unit at about 7000 ft. B unit has highest hourly cost and high average speed does not favor it much on shorter hauls. C unit is most favorable here because of its capacity and slightly lower hourly cost, although average speed is lowest.

11. In the chart below for the 5% adverse grade condition, the C unit starts out low; but the B unit crosses it at 2200 ft with an increasing lead over C as the haul length increases. The B unit is favored because of its relatively high speed on the adverse haul grades due to its greater horsepower. The C unit is a close second on the longer haul because of its higher capacity, despite its low average speed.





Transport Tows HRP-1 Piasecki Helicopter
with transmission allowing autorotation of rotors

Released Helicopter Descends Under Own Power
to spot where fixed-wing aircraft could not land

Environment Influences of HELICOPTER

AS new functions are added to the helicopter's repertoire, transmission design considerations multiply.

Now that helicopters are performing such diverse jobs as Arctic rescue, metropolitan mail service, and aircraft carrier operations, designers must consider the total environment—including such factors as ambient temperatures, probable rotor loading history, and carrier handling facilities.

Low Ambient Temperatures—For commercial and most military service, equipment must be designed for operation at temperatures down to - 30 F. For Arctic military service, design must provide for operation at temperatures down to - 67 F.

At these temperatures, lubricants become stiff—stiff enough to break small parts of the transmission. Bearings designed for oil-splash lubrication may suffer heat failure because lubricant viscosity is too high for splash during cold starting. To minimize these cold-weather lubrication troubles, the oil sump and the line to the oil pump should be designed to be readily accessible for preheating.

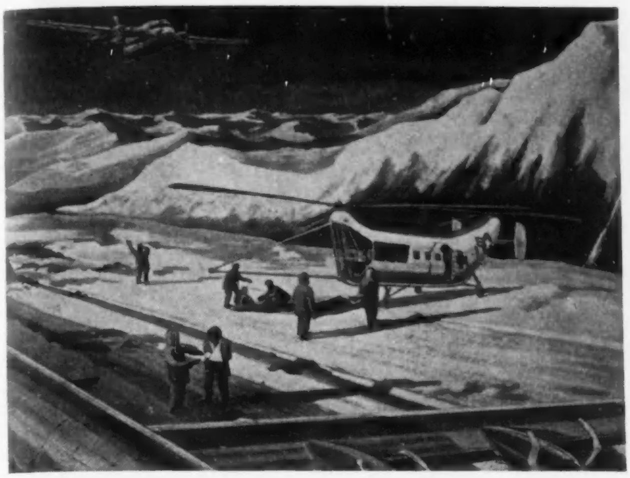
High Ambient Temperatures—The upper end of the temperature range brings the problems of preventing overheating. The designer must determine the heat generated in the gear box, the heat dissipation through radiation and convection, and the heat which must be removed by oil circulation to keep operating temperatures down to the permissible maximum—then design an oil cooler to do the job.

The maximum permissible normal gear case operating temperature for a given transmission is determined from these considerations:

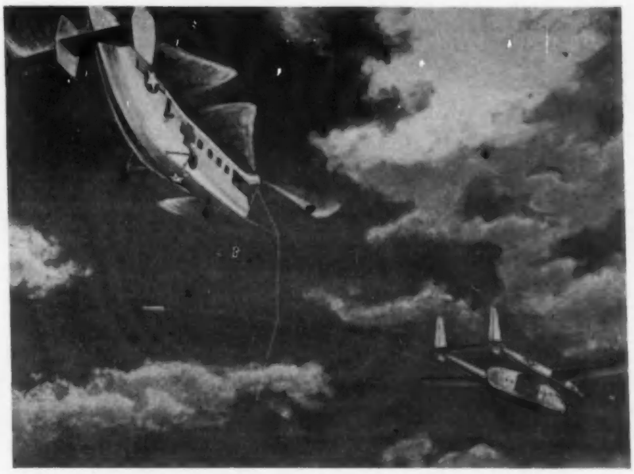
1. Temperature at which the lubricant starts to break down.
2. Temperature at which surfaces of gears suffer marked loss of wear resistance.
3. Temperature at which antifriction bearings suffer marked loss of wear resistance.
4. Temperature at which organic and synthetic materials (oil seals, bearing retainers, gaskets) begin to deteriorate.
5. Temperature at which physical properties of materials of stressed parts deteriorate critically.
6. Margin of safety required for temperature rise due to temporary malfunctions or unusual operating conditions.

Lubricating oil of Specification AN-0-9, Grade 1010, will remain stable up to 400 F, so temperature need not be limited by oil breakdown. Assuming that there is a relationship between permissible temperatures, loads, and speeds, the designer can

* Paper "The Effect of Environment on Design Criteria of Helicopter Transmissions" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



Ship Lands on Snow, and Rotors Cease Turning
until rescuers get crash survivors into roomy cabin



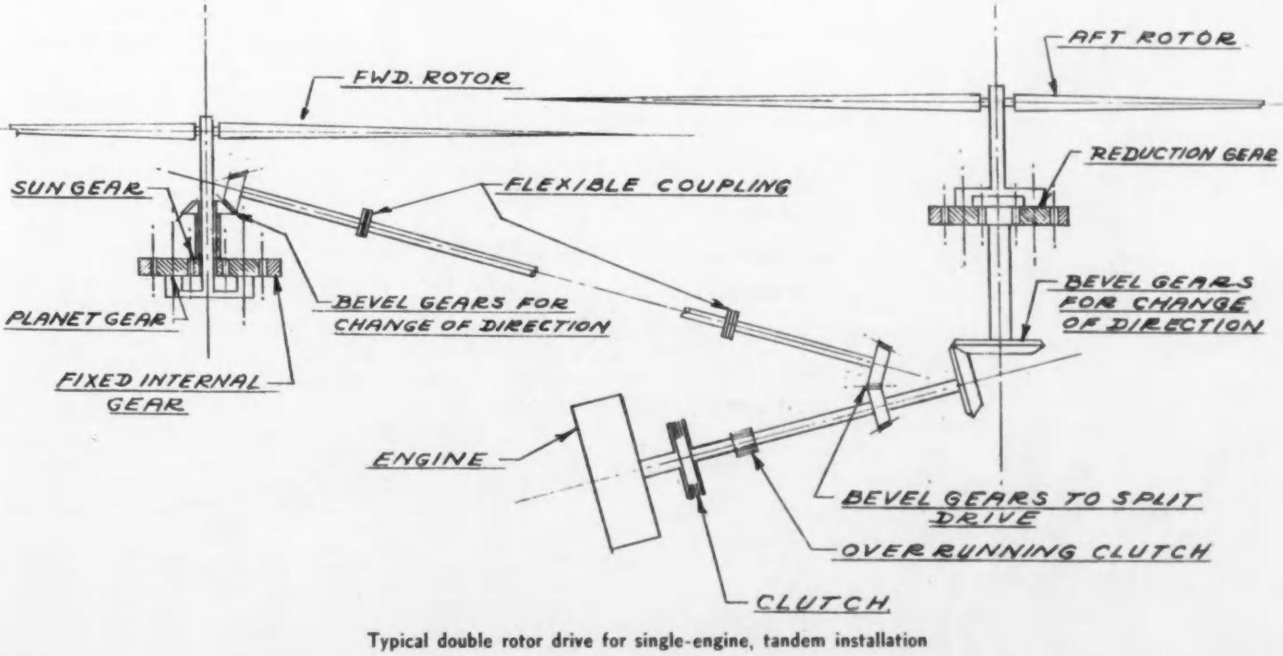
Rotors Lift Loaded Helicopter. Tow Is Resumed
when weight on line from transport intercepts drogue

BASED ON PAPER* BY

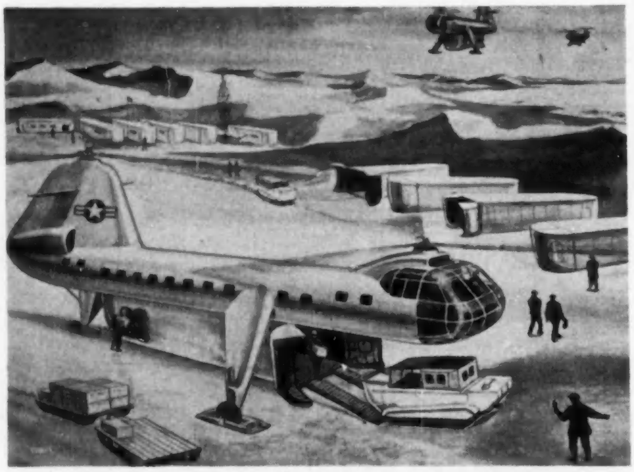
Dietrich W. Botstiber

Design Engineer in Charge of Power Transmission Group
PIASECKI HELICOPTER CORP.

Design TRANSMISSIONS



Typical double rotor drive for single-engine, tandem installation



The Proposed Piasecki Pod-Carrying XH-16
requires a transmission capable of transmitting power for lifting weighty cargo, withstanding extreme climates

minimize transmission weight by designing gears and bearings for maximum safe load and speed, and adjusting maximum oil temperature accordingly.

Piasecki Helicopter Corp. has found that if the gears and bearings of a transmission case run satisfactorily at an oil temperature of 200 F, they will also run satisfactorily at 300 F, providing that a jet spray of lubricating oil is maintained and the lubricant does not change its characteristics materially. But other nonmetallic components tend to deteriorate at temperatures over 200 F. Their failure may reduce oil circulation to the detriment of gears and bearings. Therefore, permissible oil temperature may be limited by the nonmetallic components.

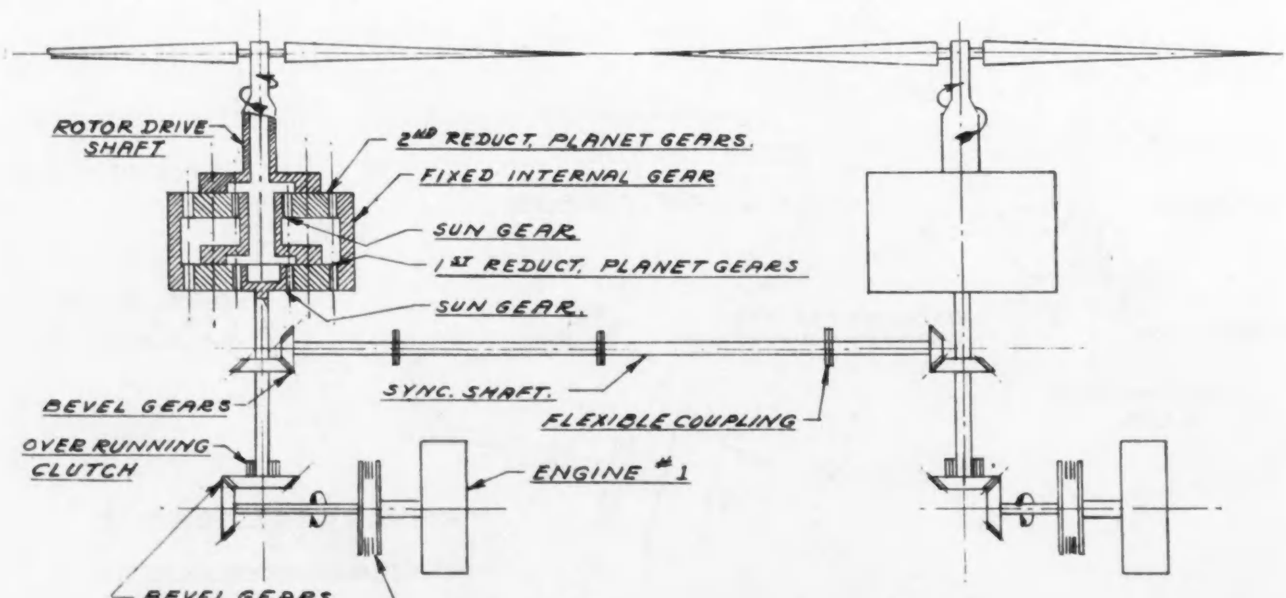
High ambient temperatures may interfere with oil pump priming. If the transmission is run at high operating temperature with compounded lubricants, then stopped, vapors of the more volatile components of the lubricant may fill the pump suction line and remain there. Then when the transmission is restarted, they prevent the liquid lubricant from entering the pump line.

The way to avoid this pump priming trouble is to locate the pump at a level lower than the sump. The closer the pump and sump and the fewer the obstructions in the line connecting them, the better.

Load Histories—To insure the desired service life, the designer must estimate what percentages of maximum load will be used over what percentages of total operating time. The type of service for which the helicopter is intended can be used to predict the load history. For example, a commercial helicopter used for mail delivery will generally perform frequent take-offs and landings. Another helicopter used for observation may make flights of longer duration but spend most of the time hovering, a maneuver that imposes 75 to 90% of maximum load. The longer the operating cycle, the more critical the transmission lubricant cooling system.

Carrier Handling Facilities—Naval aircraft carrier service requires that helicopters be started on the storage deck and warmed up on their elevator ride to the flight deck. To fulfil this requirement, the transmission must include a clutch allowing disconnection of the engine from the drive system at any engine speed and a brake for stopping the rotors quickly and holding them motionless during handling.

One type of clutch suitable for carrier-based helicopters includes a friction unit for starting, a positive jaw clutch to take over after the driving and driven shafts are synchronized, and a system of cams for sequencing clutch engagements.



Transmission for tandem rotor helicopter with engine for each rotor

Developing Charts for Quality-Control Work

EXCERPTS FROM PAPER* BY **R. S. Saddoris**

Director of Quality
A. O. Smith Corp.

JUST how can statistical methods be used to supplement the experience of the man called upon to make quality decisions? We can never be too certain of the job knowledge that he possesses. A decision to reject calls for delayed production, additional costs. A decision to accept entails the risk that the customer later may not agree with the decision and that extra costs will be incurred to adjust the disagreement, plus some loss of customer good will. There is always present an inherent risk in every decision, and this risk is necessarily greatest at the start of production when we lack the knowledge acquired from production experience. Standard sampling plans have been developed in which such risks of erroneous decisions are calculated mathematically, and by which the "going in" risk can be minimized with a minimum amount of inspection.

Let us consider a series of charts designed to show how the $\overline{X}$ or control chart for averages might have developed. Assume that there is on hand in your plant a quantity of steel and you want to know whether or not it is of the correct thickness for a specific job. You hand a micrometer to an inspector and ask him to check some of it and give you a report. In due time he will provide you with a tabulation of figures much like Fig. 1.

It is a pretty good report. He has checked a lot of pieces. Now what do we do with it?

The trained man will instinctively seek out the smallest and the largest value. He spots a 0.104 and a 0.116 and concludes that his steel ranges in thickness between these two dimensions. But he also wants to know about how much steel he has of each thickness. To find out he usually winds up by rewriting the report.

Suppose now that we had given our inspector more-specific instructions and had told him to prepare a check sheet before he took any measurements. Using a piece of cross-section paper, he could show on the left-hand margin all of the thicknesses he was likely to find. Then, as he measured each sheet,

.114	.107	.110	.112	.112	.107
.110	.108	.114	.104	.113	.114
.104	.107	.106	.109	.108	.113
.111	.112	.115	.115	.111	.110
.113	.117	.110	.111	.108	.109
.106	.110	.111	.114	.116	.110
.115	.111	.112	.114	.113	.105
.107	.117	.113	.116	.110	.109
.112	.110	.113	.109	.114	.110
.107	.109	.111	.116	.110	.108
.107	.107	.105	.111	.112	.108
.112	.115	.111	.111	.110	.113
.108	.109	.108	.112	.113	.106
.114	.109	.104	.114	.108	.112
.112	.108	.110	.110	.114	.109
.114	.114	.107	.109	.113	.111
.110	.115	.111	.109	.112	.109
.108	.113	.111	.112	.112	.112
.118	.110	.110	.111	.107	.106
.103	.107	.114	.117	.109	.113
.113	.112	.106	.113	.112	.108
.111	.106	.114	.111	.109	.109
.111	.109	.114	.107	.113	.115
.109	.116	.108	.107	.112	.110
.108	.116	.113	.108	.111	.108
.113	.111	.110	.112	.107	.108
.110	.110	.116	.110	.111	
.109	.108	.115	.109	.109	
.107	.108	.108	.111	.108	
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.111	.109	.113	.109	.110	
.113	.110	.113	.105	.111	
.114	.112	.106	.109	.112	

Fig. 1—Typical inspection report—check sheet showing thickness of a quantity of steel sheets

* Paper, "Quality Control and Inspection," was presented at a meeting of the Milwaukee Section of the SAE, Milwaukee, Wis., Nov. 4, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

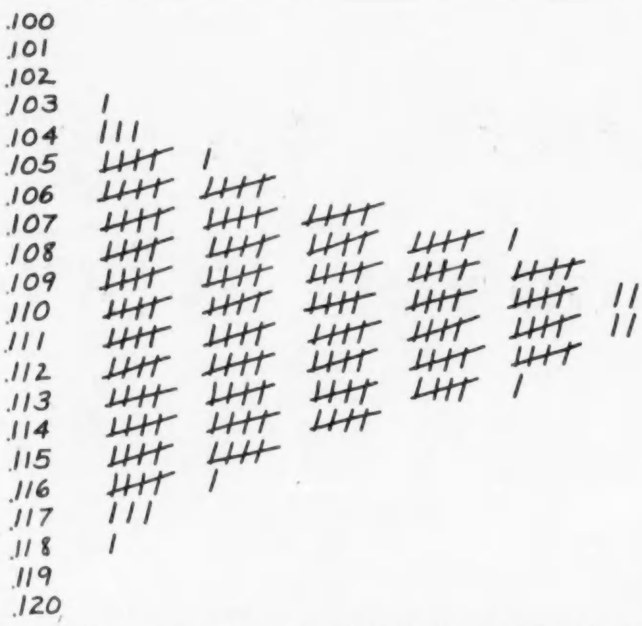

Fig. 2—Histogram—this chart shows identically the same information as typical inspection report and scatter chart

he could place a check mark or an *X* in one of the squares opposite that value. When he was finished he would turn in a report something like Fig. 2.

Many of you have used similar tabulations, but how often have you seen an inspection report in this form? It shows exactly the same information as the accumulation of figures but it is a much more valuable report in many ways. At a single glance the high and low values are known; likewise, it can be seen in this case that the average value is midway between these extremes. The amount of variation is easily seen and the number of pieces of each size is quickly determined. No further work is needed. And because it requires a lot less writing, the possibility of error is much less.

It tells us something else. Please note the outline. It has a meaning, and we will refer to it again. Quality-control people call it a histogram.

Now consider Fig. 3. It is a form of control chart that might also be called a scatter chart.

This is rather confusing, and although many of us have used such a chart at one time or another, it is not in general use in quality-control work. It is shown at this time for another purpose. It shows exactly the same information as the two previous charts but in a different manner. Along the left-hand margin, we scale the same values as before but instead of placing our check marks adjacent to each other we have plotted them in the order in which the measurements were taken. The horizontal scale is in some kind of time units. There are 216 such measurements. Imagine each of these dots as a bead strung on a wire. Imagine further that we could slide all of these breads along wires to the left; bunching them, in other words. What would be the result? Fig. 4.

Note that the outline we obtain is the same as the inspector's histogram. Let us now draw a smooth curve connecting the high points of this histogram and we have a normal frequency distribution curve, sometimes referred to as the Gauss curve, from the name of the man who is said to have developed it a hundred or so years ago.

This curve has several very valuable properties, which we utilize in quality-control work. It can be divided into two equal areas by a line representing the average value of all of the variables under the curve.

It is further divisible into six areas of equal width,

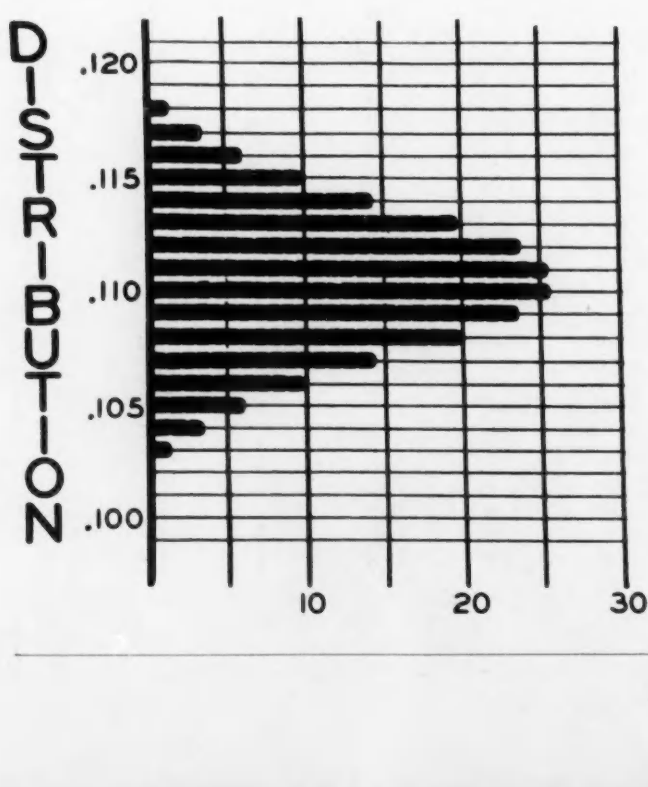

Fig. 3—Frequency distribution curve (normal curve)—this chart shows what happens when all points shown on scatter chart are bunched together. Verify by counting number of rows and points on each row. Compare with histogram

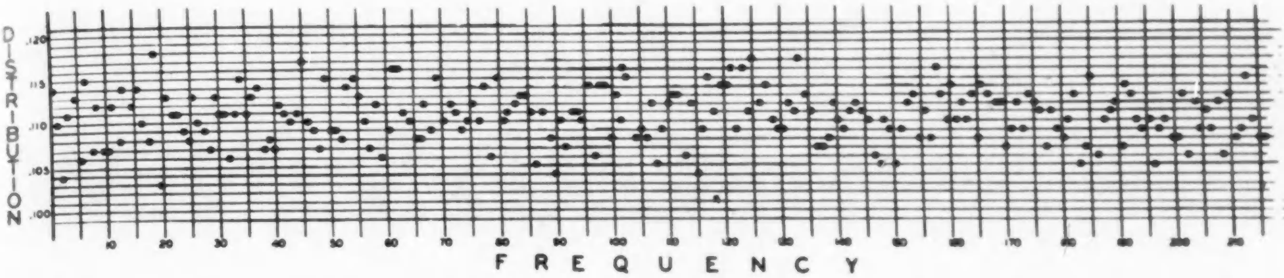

Fig. 4—Scatter chart—this chart shows identically the same information as inspection report. Not generally used in quality-control work but is important in developing frequency distribution curve and control chart

each representing a unit of measurement known as the standard deviation. Quality-control people call this sigma. It is calculated in much the same way as is the moment of inertia. It is a mathematically exact value uninfluenced by personal judgment or opinion. The area is each of these divisions represents an exact percentage of the total area under the curve. 68% of the total area lies between plus and minus 1 sigma, 95½% between plus and minus 2 sigma, and 99¾% between plus and minus 3 sigma. ¼ of 1% lies under the two tails of the curve, which stretch out to infinity and never quite touch the base line (Fig. 5). This is another way of saying that anything that can happen will happen.

Let us now look at the form of a control chart. At first glance it is not readily associated with the normal frequency curve, but we showed a moment ago how the points that make a normal distribution can be plotted on a time basis to assume the control chart from (Fig. 3). The averages are common to both delineations. The control limits of the control chart are identical to the plus-and-minus three-sigma values of the distribution curve. Imagine a normal distribution curve with pieces of chalk fixed on the base line at the average value, the plus-3-sigma value, and the minus-3-sigma value. Rotate the entire curve clockwise through 90 deg., and pull it to the right. The chalk will draw the average and control lines for the standard control chart to use for that frequency distribution.

Each population has at least two distribution curves. We have been talking about the basic curve or the curve for individuals. The other curve is that derived by sampling the population, calculating the average of each sample, and plotting the average values in histogram form. Both curves have the same grand average. The second curve (derived by plotting averages) is much more narrow in spread than the first (population) curve. There is a definite mathematical relationship between the two spreads. An $\bar{X}$ chart in quality-control work is based on the second curve. There are two good practical reasons for doing this:

1. The resulting curve is more likely to be normal than is the population curve, thereby enhancing the accuracy of decisions based on it.

2. It is more sensitive to fluctuations in the underlying population than is the basic curve.

We have touched lightly upon some techniques used in quality-control work. Some control charts other than the $\bar{X}$ chart are the C chart or defects-per-unit chart and the p chart for per cents defective. There are variations of each.

Sampling plans based on the Dodge-Romig, Army Ordnance, and other tables are universally used. There are single and double sampling, and sequential sampling plans. A sampling plan can be constructed for almost any sampling problem.

There are also the powerful analysis of variance and correlation analysis techniques used extensively in the paper, chemical, food, and other continuous—process industries. Each has its place; all are valuable; but boiled down they aim to accomplish just one thing: to provide factual information from which corrective action may be taken. Find it and fix it, is the job.

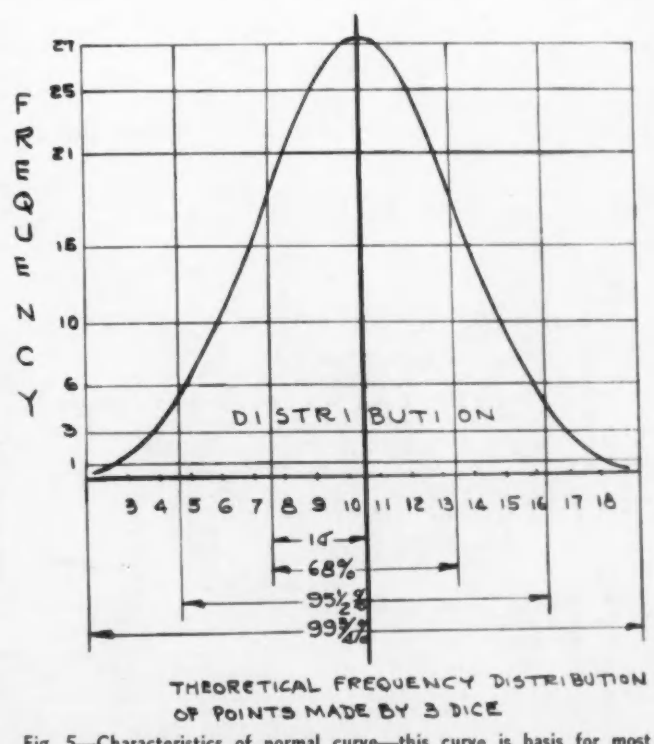

Fig. 5—Characteristics of normal curve—this curve is basis for most quality-control work. It illustrates theory of normal frequency distribution

FORD'S NEW

EXCERPTS FROM PAPER* BY

C. W. Rainey

Supervisor, Electrical Systems Section
Electrical Engineering
Ford Motor Co.

THE full vacuum controlled ignition system now used in Ford cars and trucks, makes for simpler ignition distributor design, longer distributor life, and easier service. It does so by providing spark advance with a single actuating force rather than with the two independent means of conventional distributors.

The conventional ignition distributor has centrifugal weights to give spark advance that satisfies full-power requirements of the engine. The manifold vacuum system satisfies the additional advance requirements of part-load operation. The single spark advance actuating force in the full vacuum control system takes the form of a vacuum diaphragm controlling the breaker plate position. This diaphragm is actuated by a controlled differential vacuum, derived in the carburetor through the use of specially drilled orifices which are interconnected in the carburetor body. The relationship of the vacuums produced for various speeds and loads are determined by the size and placement of these ori-

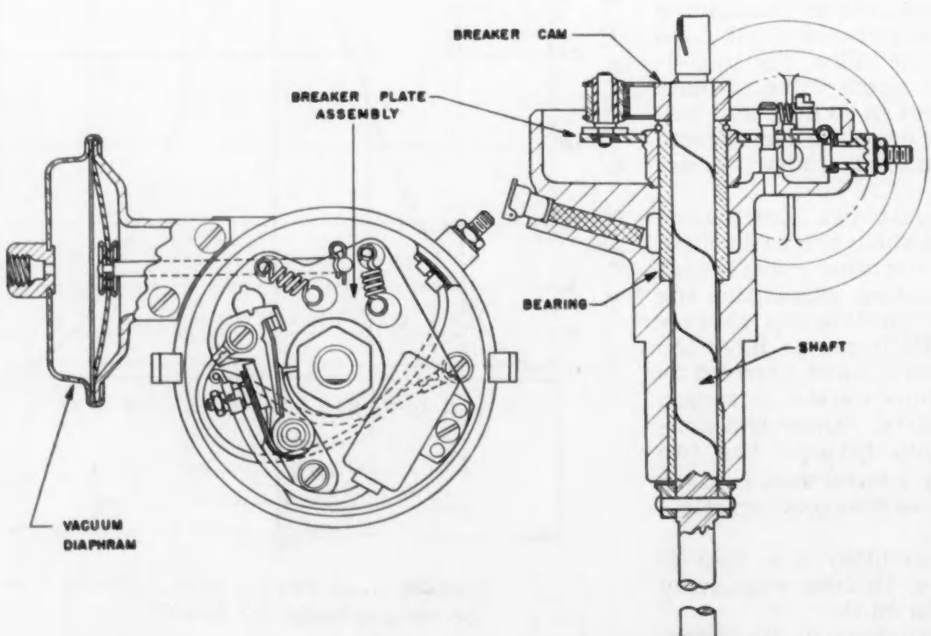

Fig. 1—Constructional details of full vacuum controlled distributor showing principal assemblies

* Paper "Full Vacuum Controlled Ignition System," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

IGNITION SYSTEM

fices in the carburetor, so that the differential vacuums produced will be a function of engine speed and load conditions. For this reason the carburetor must be engineered for a specific type of engine to meet the requirements of that engine.

Fig. 1 illustrates a cut-away section of a typical full vacuum controlled distributor showing its principal parts and assemblies. The design is such that the breaker cam is fixed to a solid distributor shaft and can at no time vary in position from the driven end of the shaft. This means that good concentricity tolerances may be maintained between the breaker cam lobes and shaft.

This was not always true in systems used in the past where additional tolerances must be considered due to the cam movement in respect to the shaft. The fixed cam to shaft relationship also eliminates wear considerations in service. This construction eliminates the possibility of torsional vibration, appearing at the driven end of the distributor shaft, from being amplified at the breaker cam. (Such is the case where centrifugal weight governors are employed, due to the coupling necessary through the breaker springs and connecting parts and bearings.) Spark scatter or spread from this cause is held at a minimum.

The breaker plate assembly includes the breaker contacts and condenser, and rotates about the cam to produce spark advance. The breaker plate is restrained in its movement by springs from a fixed or initial timing position. The springs are chosen as to rate and free length to permit a reasonable lati-

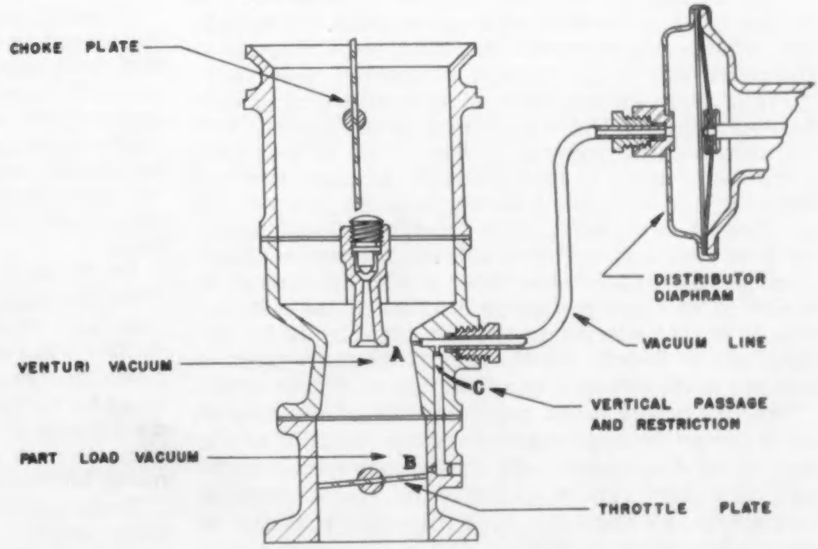

Fig. 2—Special passages are drilled in the carburetor for full vacuum control of the distributor. The throttle plate is in the closed position in this diagram, as it would be under idling conditions

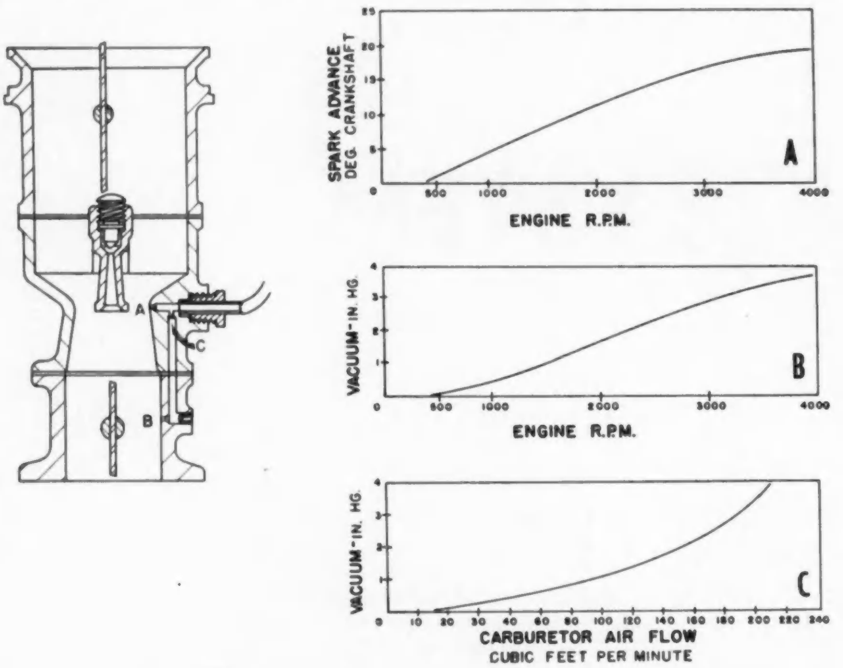

Fig. 3—For wide-open throttle carburetor operation, diagrammed at left, the performance in the charts at right result. They are: (A) spark advance versus engine speed produced by carburetor differential vacuum for wide-open throttle operation; (B) resultant carburetor differential vacuum for wide-open throttle operation versus engine speed; and (C) resultant carburetor differential vacuum for wide-open throttle operation versus cubic feet of air per minute through the carburetor

tude in adjusting spark advance to meet the requirements of the engine. The distributor vacuum diaphragm is connected by a rod linkage to the breaker plate. This diaphragm is vented to atmosphere on the distributor breaker plate side, and is actuated by the distributor differential carburetor vacuum on its closed side.

Carburetor Considerations

The vacuum control for this ignition system is one of the major considerations in its application. Its design must be carefully integrated with the distributor design to meet the sparking requirements of the particular engine that it is required to serve.

Fig. 2 represents a cross-section of a typical carburetor showing the positioning of the special distributor vacuum passages. We notice at (A) that a drilling is made at the throat of the main venturi. Here we find that air passing through the venturi produces a depression as a function of carburetor air flow which is, in turn, related to engine speed. If only this orifice were used, a vacuum would be produced at the distributor diaphragm as a function of engine speed and this, in turn, could be applied to the distributor breaker plate movement to produce spark advance as a function of engine speed.

The full power spark requirements of the engine could be met by applying the venturi vacuum to the distributor diaphragm with the proper spring loading. However, this would give us spark advance comparable to that obtained through the use of centrifugal weights only at full power and would not satisfy part-load requirements of the engine.

A second orifice is drilled at (B) into the throttle body slightly above the closed throttle plate position. This senses manifold vacuum present in the throttle body above the throttle plate. It is blocked off by the throttle plate in its closed position, where no vacuum appears in the system, and spark advance is at full retarded due to the action of the breaker plate springs. The manifold vacuum orifice is interconnected to the venturi orifice through a vertical passageway designated by (C) in the diagram. A restriction is placed in the upper portion of the vertical passageway between the two orifices.

The orifices are affected by each other under various speed and load conditions of the engine. During wide-open throttle operation, the resultant manifold vacuum is less than that developed in the venturi and air flow occurs from (B) through the vertical restriction at (C) and out at (A). The restrictions presented by these three orifices determine the amount of bleeding one will produce on the other and their hole sizes must be carefully worked out.

If (B) and (C) are large with respect to (A), a large amount of bleeding will occur and the resultant vacuum applied at the distributor is low and a weak spring adjustment must be used to provide a given degree of spark advance. Conversely, if orifice (A) is made large with respect to (B) and (C), we can expect an increase in distributor carburetor vacuum and a heavier spring adjustment must be made for the same degree of advance.

Under part-throttle operation, particularly at the lower engine speed ranges, the manifold vacuum sensed at (B) is many times greater than that developed at the venturi, and air flows into the venturi orifice down through the vertical passageway and

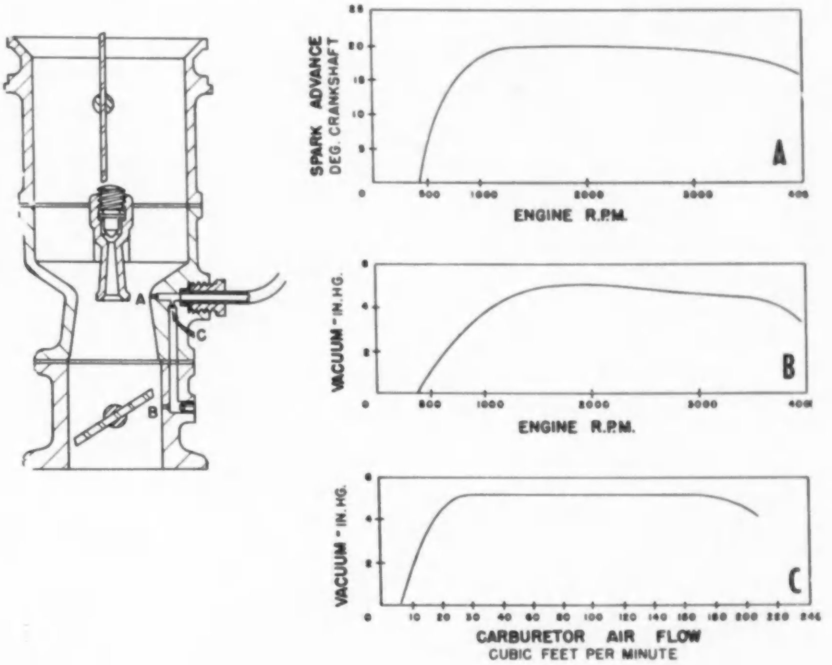

Fig. 4—Part-throttle carburetor operation, shown schematically, produces the performance in the charts at far right. (A) is spark advance versus engine speed produced by carburetor differential vacuum for vehicle road-load operation; (B) carburetor differential vacuum for road-load operation versus engine speed; and (C) carburetor differential vacuum for road operation versus cubic feet of air per minute through the carburetor

out at (B). We find (A) is now bleeding the higher vacuum at (B) and again the relative sizes of their restrictions are important.

If (A) and (C) are large with respect to (B), the carburetor distributor vacuums produced are low. For a given spring adjustment under wide open throttle conditions, the resultant part throttle spark advance would be lower than that produced if their relative restrictions were reversed. If restrictions (B) and (C) are made larger with respect to (A), higher part throttle distributor vacuums will result and a higher part throttle spark advance is obtained.

In Fig. 2 the carburetor was diagrammed showing a closed throttle plate position, which is the case under engine idling conditions. This results in engine manifold vacuum being removed at the throttle body orifice. Since no depression exists at the venturi, there is no actuating force applied at the distributor diaphragm and the spark timing is fully retarded.

Wide-Open Throttle Operation

Wide-open throttle carburetor operation is diagrammed in Fig. 3. Here, a relatively high venturi vacuum is developed over the speed range of the engine with attendant lower manifold vacuum being present in the carburetor throttle body, and controlled bleeding of the venturi results. This differential vacuum is applied to the distributor advance diaphragm.

Fig. 3C diagrams the resultant distributor differential vacuum referenced to air flow through the carburetor in cubic feet of air per minute.

Fig. 3B illustrates the distributor differential vacuum in terms of engine rpm when the carburetor is operated in conjunction with a specific engine at full power.

Fig. 3A illustrates distributor spark advance determined by the differential vacuum, described in Fig. 3B, reacting against the spark advance breaker plate springs within the distributor. The distributor spark advance springs have been adjusted to meet the sparking requirements of the engine for wide-open throttle or full power operation.

Once this relationship has been established, it is necessary in the carburetor design to produce differential carburetor vacuums which will further advance the spark timing to satisfy road-load and part-load engine spark advance requirements. This can only be accomplished through design of the orifice at (A), (B), and (C) to produce the correct relative vacuum relationships for full and part-throttle operation.

Part-Throttle Operation

The schematic diagram of Fig. 4 illustrates the throttle position for part-load operation. Here, the throttle has been advanced from its closed position to uncover the manifold vacuum orifice. The manifold vacuum in the throttle body increases due to lighter engine loading and greater vacuums will be sensed by this orifice.

If the manifold vacuum present at (B) becomes greater than that present at the venturi, air flow will result from the venturi through the manifold vacuum orifice. We now have the venturi orifice bleeding the manifold vacuum orifice and controlling the resultant differential vacuum present at the distributor diaphragm. The only condition where no air flow is resulting in the vertical passageway

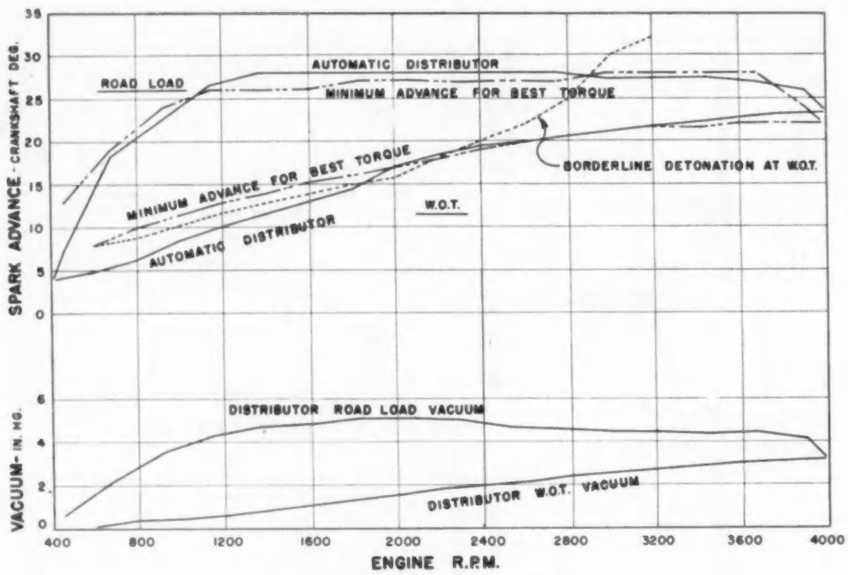

Fig. 5—Charted here are results from dynamometer operation of a typical L-head engine. They include differential vacuums and resultant spark advance for full-load and road-load engine operation, minimum spark advance for best torque obtained by manual distributor operation, and borderline detonation at full power operation

(C) is when the developed venturi vacuum for any given speed equals the manifold vacuum present in the throttle body.

Examination of Fig. 4C will show the resultant differential vacuums produced for carburetor air flow in terms of road-load power requirements. The slope of this curve advances rapidly as the throttle plate uncovers the manifold vacuum orifice at a relatively low carburetor air flow. This cut-in characteristic is determined by the placement of the manifold vacuum orifice above the closed position of the throttle plate. Since its drilling is made higher in relationship to the closed position of the throttle plate, the differential vacuum and resultant spark advance cuts in at a higher carburetor air flow.

It is also possible to vary the slope at the cut-in point by changing the shape of the manifold vacuum orifice. If a horizontal type slot is used instead of a circular hole, the slope of the curve tends to be more abrupt and steep. If the orifice is made in the form of a vertical slot, the slope of the curve is decreased as the orifice becomes less sensitive to throttle plate position. The distributor differential vacuum is controlled in its maximum value by the relative bleeding that occurs under road-load conditions.

Fig. 4B illustrates the resultant distributor differential vacuums produced by the carburetor referenced against engine speed for vehicle road-load operation.

Fig. 4A describes the resultant spark advance in terms of engine speed produced by the applied distributor differential vacuums.

Fig. 5 shows the resultant spark advance obtained with a typical L-head type engine over its normal speed range. The minimum spark for best torque requirements was determined through the use of a manual distributor. Rerunning this engine with full automatic spark control has produced very close approximations of the desired spark advance for both full power and road-load engine operation. These conditions may be readily realized for a particular type of engine through proper carburetor and distributor design.

At part loads and low engine speeds, the sparking requirements and automatic spark do not always find such complete agreement as at full and road-load operation. There is a tendency for this distributor to be over-advanced at low speed partial loads approaching the full power requirements. This will be readily understood when it is remembered that increased manifold vacuums from wide-open throttle rapidly approach the developed venturi vacuum and exceed it, while the sparking requirements of the engine have not materially increased. The conventional type distributor, due to its preloaded vacuum diaphragm, is usually under-advanced for the same conditions. The spark advance remains at that produced by the centrifugal weights and no advance occurs until the manifold vacuum has built up to relatively high value.

A similar type operation can be produced in the full vacuum ignition system by introducing a small poppet valve, actuated by manifold vacuum, in the vertical passageway. This prevents manifold vacuum from affecting the venturi orifice until the poppet valve spring is deflected due to higher manifold vacuums. At this time, the vertical passageway is cleared and the carburetor differential vacuums are produced in their normal manner. To date, experience on L-head engines has shown that this is not a necessity and, therefore, has not been used in current designs.

The full vacuum control ignition system has its advantages as well as its disadvantages, which must be taken into account in its application.

Its advantages are:

1. Simplification of assembly details of the distributor system.
2. Elimination of centrifugal weight spark advance mechanisms.
3. Longer life of wearing parts.
4. Employment of a single spark advance mechanism within the distributor.
5. Establishment of a definite relationship of full and part-load differential vacuums within the carburetor.
6. Simplification of service re-adjustment procedures.
7. Fewer parts in assembly to be reworked if service overhaul of the distributor is necessary.
8. Unaffected by torsional vibration causing spark timing spread through elimination of centrifugal weight assemblies.

Its disadvantages are:

1. De-acceleration with closed throttle plate position fully retards the spark to the initial engine timing.
2. The distributor rotor position is fixed in its relationship to the distributor driving shaft and rotor sparking to terminal housing post varies throughout the entire timing range.
3. Additional vacuum passages must be introduced into the carburetor design to supply the differential distributor vacuums.

Discussion

Special Carburetor Design Seen Limiting System's Use

Based on discussion by

L. H. Middleton

The Electric Auto-Lite Co.

The conventional combination ignition control system in its modern form is a practical, rugged and long-lived mechano-vacuum control readily adaptable and changeable to the varying conditions demended in internal combustion engines of many cylinder combinations in use in all parts of the world.

The full vacuum control system, while somewhat more simple in its mechanical details, requires a more precise and complex application than does the so called combination unit. As Rainey points out, operation of the full vacuum system is completely dependent upon the differential vacuum produced in the carburetor; response must be to low orders of energy; and the distributor is no longer an independent spark advance system, but is a combination ignition and carburetor responsive device, which is dependent upon the design of the carburetor and the precise application and location of orifices engineered within the carburetor.

The inter-position of a secondary functional device between the distributor and the engine proper —the carburetor, cannot help but complicate both the application to, and the operation on, volume-produced engines, where variations in manufacture will affect to some extent, the differential vacuum available as functions of differences in manifolding and inter-cylinder stability.

In addition, in the writer's opinion the total energy available at wide-open throttle is insufficient to guarantee stability and permanence of spark advance characteristics, particularly in view of the variable frictional component known to result from tolerances in manufacture, normal wear and varying degrees of lubrication.

Full Vacuum Control Weaknesses Explored

Based on discussion by

H. L. Hartzell

Delco-Remy Division, GMC

With the full vacuum system, the timing accuracy is a divided responsibility, since part of the control is in the carburetor and part is in the distributor. It is easy to see that the ignition equipment manufacturer and the carburetor manufacturer could do a swell job of "passing the buck" on any service complaint, and would have difficulty deciding whose responsibility it is when a change in timing is required.

Rainey stated that with the full vacuum system there is a tendency to be over-advanced in the low speed range at loads between road load and full load, and that with the conventional system there is a tendency to be under advanced.

This under-advanced condition with the conventional system is not a shortcoming of the system, since advance can be obtained—and is obtained—at vacuums as low as 3 in. hg. True, many engine designers specify the vacuum advance to cut in the region of 6 to 8 in. hg; but this is undoubtedly due to their caution in keeping away from part-throttle detonation.

Rainey also said there is a problem of spark timing spread due to torsional vibration being transmitted from the engine when a centrifugal advance control is used. The spring weight and cam combination that we use is not as good an oscillatory system as many people seem to believe. The lever ratio between the weights and the cam changes rather rapidly. Consequently, any movement changes the resonant frequency of the system. I do not recall any case of excessive spark variation with our equipment that was significantly reduced by blocking the action of the centrifugal advance mechanism.

ENGINEER'S FORUM

On Diesel Piston-

BASED ON PAPER* BY

A. M. Brenneke

Chief Engineer,
Manufacturers' Department,
Perfect Circle Corp.

How Diesels Wear . . . What to Do About It

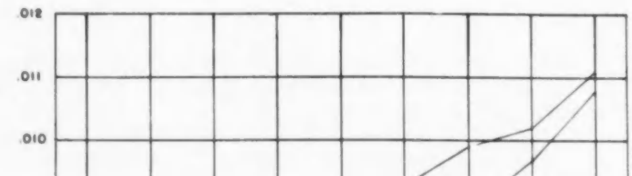

Fig. 1—Test data showing the effect of coolant temperature on cylinder wear rate in two engines. Each curve represents the wear rate in one cylinder

THE drive toward piston ring and cylinder wear reduction in diesel engines is taking on added impetus because more is being learned about three phases of the problem: (1) basic causes of cylinder wear, (2) how piston rings affect cylinder wear, and (3) how piston rings can be designed to minimize cylinder wear.

There are three generally recognized causes of cylinder wear—abrasion, corrosion, and scuffing.

Abrasive cylinder wear is largely caused by airborne dirt. Engine air supply must be kept clean if low cylinder and piston wear rates are to prevail. Abnormal wear rates may be expected if dirt is admitted in amounts greater than 0.00025 g per cu ft of air. This applies to air after it leaves the filter and as it enters the engine, and refers to abrasive particle size of 5 microns or less. Larger particles would be damaging in even smaller quantities.

Dirt in the lubricating oil also may accelerate cylinder wear; but its effect on crankshaft and bearings is much greater.

Corrosion is probably the second most important contributor to cylinder wear. Most predominant corrosive wear cause is low coolant temperature due to design or, more often, to operating conditions. Abnormal corrosive wear generally becomes apparent at 120 F or less. Jacket temperatures should be maintained at 160 F or higher for lowest cylinder wear.

Fig. 1 illustrates the effect of coolant tempera-

* Paper "Piston Ring Design and Application and Their Effect on Wear," was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Piston-ring designers and engine men dip into their bag of experiences to explain diesel engine wear causes and cures in this article. Brenneke kicks off this editorial round table with a basic diagnosis-cure exposition and on the following pages nine other specialists in the field amplify knowledge on the problem.

Ring and Cylinder Wear

ture on cylinder wear rate in two engines which were subjected to 1000-hr cyclic dynamometer tests simulating city bus operation. Each engine was equipped with different cylinder liner materials and each engine contained three widely different compression ring combinations. The tests were run at over 160 F water-out temperature, except during the 300 to 400-hr period when it was reduced to 120 F. Only 800 test hours are plotted since it is sufficient to illustrate the point. Wear curves for all 12 cylinders are plotted together purposely to show the uniformity of pattern.

Note that the wear rate increased in all but three cylinders during the period of low jacket temperature, and that the rate of change was similar despite great variation in level before and after the low temperature period. The few exceptions to the rule probably are due to slight errors in measurement or differences between individual cylinders in cooling characteristics.

Increased wear rate was evident, but less pronounced, on the rings. Low jacket temperature usually affects rings less adversely than cylinders.

High sulfur diesel fuels are rapidly overtaking low coolant temperatures as a cause of cylinder and piston-ring corrosive wear. Fig. 2[1] shows the effect of high sulfur diesel fuel on cylinder and ring wear. Corrosive effect of oils designed to counteract high sulfur fuel also is shown. The black bars on the graph may be considered to represent a normal

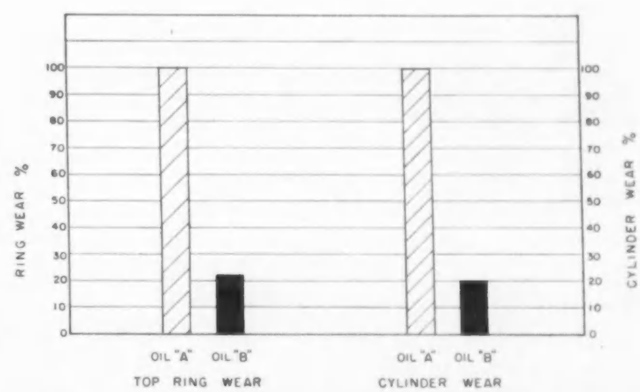

Fig. 2—Wear with high sulfur fuel can be minimized with corrective lubricants, these data show. The black bars can be said to indicate a normal wear rate

[1] From paper "Piston Ring and Cylinder Wear in Diesel Engines," by John W. Pennington, presented at SAE National Tractor and Diesel Engine Meeting, Sept. 8, 1948.

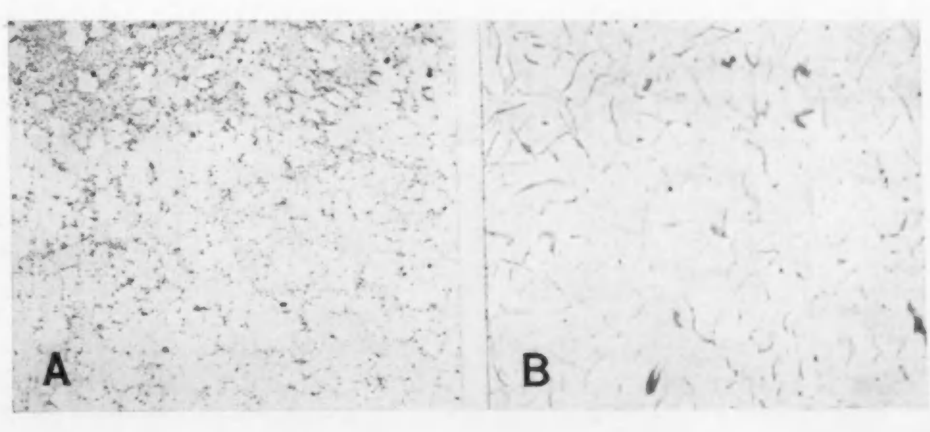

Fig. 3—The chill cast cylinder liner material in "A," with fine sparsely distributed graphite, leads to high wear rates. The structure in "B" is much less conducive to scuffing wear

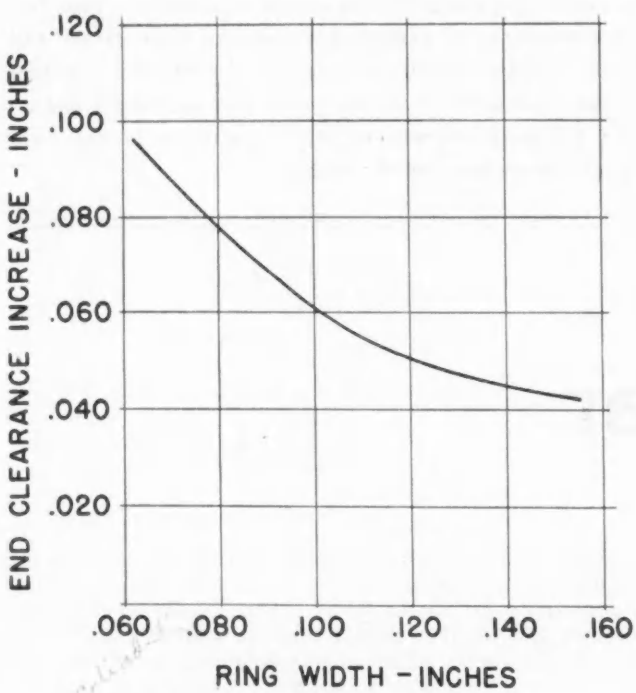

Fig. 4—How ring widths is related to wear rate

wear rate. These data have been well confirmed in many other engines. Fortunately, the effect of high sulfur fuels seems to have been brought under control by developments in lubricating oil.

Scuffing, the third wear cause, might seem out of place here if we limit it to consideration of normal wear, since in its most recognizable form it is so destructive as to be classified as a design consideration rather than a wear problem. But since some engines suffer from an incipient form of scuffing, which is difficult to distinguish from normal wear, perhaps it should be mentioned. These problems may stem from cylinder finish, cylinder material, cylinder design, ring material, ring application, or various combinations of these factors.

Fig. 3A shows a type of chill cast cylinder liner material that has been found to produce scuffing and/or very high wear rates. Note the very fine form of graphite and its scanty distribution. Fig. 3B depicts a more desirable structure which has much better scuff resistance and lower wear rate. Chemical composition of both materials is essentially the same. The improved graphitic structure is the result of a slower cooling rate in the casting process.

In service, 0.001 in. per 1000 miles has been observed to be about an average wear rate for the chill cast material referred to in Fig. 1, while 0.0001 in. per 1000 miles would be a fair value for the gray cast material.

Answer to the second part of the wear problem (how ring design and application affect wear) boils down to this: Piston ring design and application determine wear of parts as they affect the parts' susceptibility to the basic wear causes. In most types of wear, anything that reduces ring wear also cuts down cylinder wear.

As to wear reduction through piston ring design and application, let us first consider what can be done to improve resistance to abrasive wear. Here top compression rings are the most important consideration. Anything we do to reduce their wear

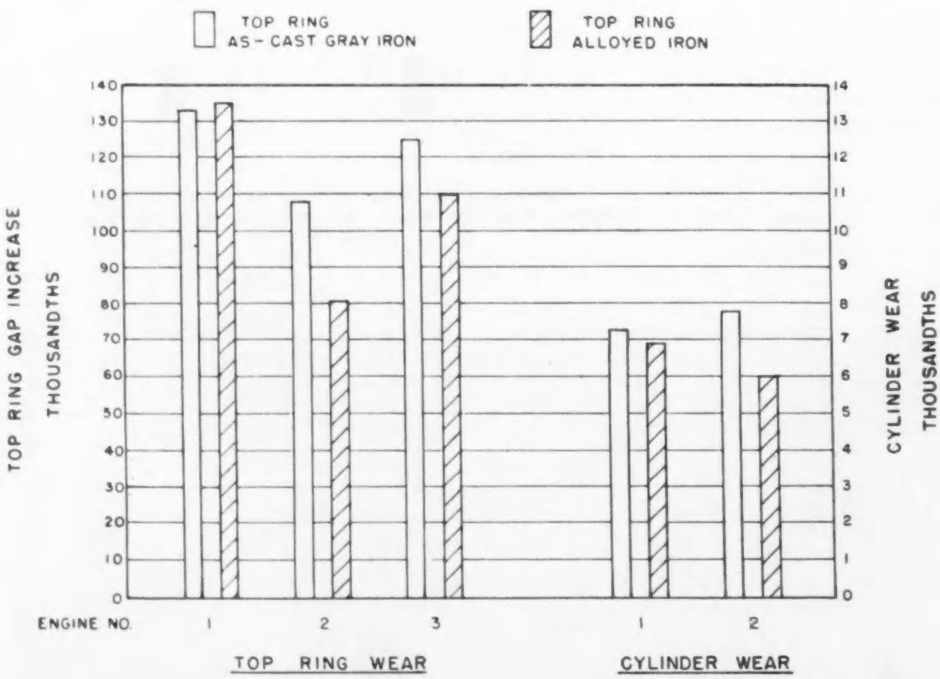

Fig. 5—Test data comparing alloyed cast-iron compression rings with those of as-cast gray iron. This test consisted of five 6-cyl engines using top rings of each type in alternate cylinders. Tests were run for 3700 to 5000 hr

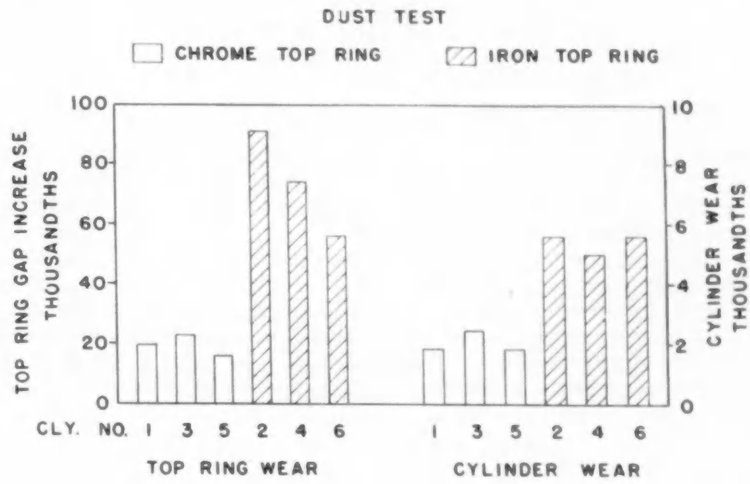

Fig. 6—Comparing alloyed top rings versus chrome-plated rings as to cylinder and ring wear

rate also reduces cylinder wear.

Top ring width should be as great as permitted by output, scuffing tendencies, and space limitations of the engine. Reason for this shows up in Fig. 4, which illustrates the relation of ring width to wear rate.

Also important is the selection of material for top rings. For the past 10 years we have used a heat-treated chrome-moly alloy cast-iron material for all diesel compression rings. Wear rate of this material is compared with that of as-cast gray iron ring material in Fig. 5.

During the past five years chrome-plated top compression rings have been widely adopted in diesels. Fig. 6 compares the cylinder and ring wear rates of chrome-plated rings and the previously mentioned alloyed ring material. Plated and unplated rings were used in alternate cylinders. Such rings are plated with 0.004 to 0.007 in. of solid, rather than porous, chrome plate. We have made and used both types, but prefer the solid type for maximum scuff resistance and minimum wear rate. A few applications demanding extremely long life are using a 0.008-in. minimum plate thickness.

Design and application of piston rings for maximum scuff resistance generally conform to the same rules as design for abrasive and corrosive wear. Selection of ring width is one exception. Wide widths of top compression rings are desirable from the standpoint of abrasive wear resistance, while narrow rings are desirable for scuff resistance. In fact, the curve for scuff resistance versus ring width would probably look very much like the curve for wear versus ring width shown in Fig. 4, with scuff resistance increasing as width decreases.

This complication is circumvented in some cases by cutting grooves in the ring face to interrupt the continuity of metallic surfaces. The grooves are filled with a mixture of black magnetic iron oxide (Ferrox) bonded with sodium silicate. Fig. 7 shows

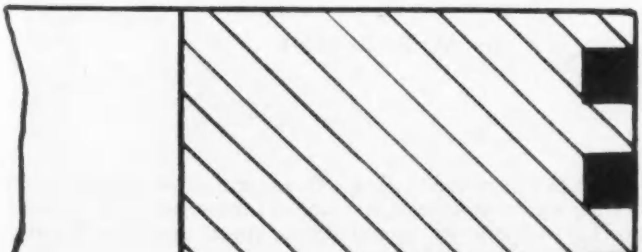

Fig. 7—As a scuff resistance measure, rings can be grooved and filled with a magnetic iron oxide mixture bonded with sodium silicate

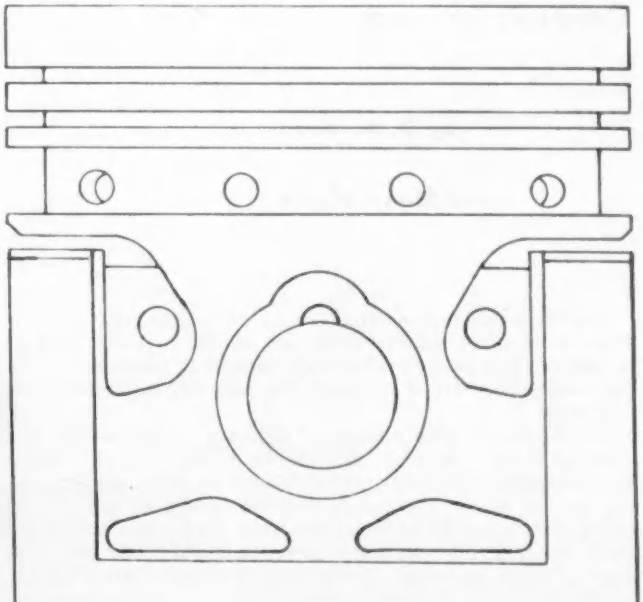

Fig. 8—Experimental tests with two oil rings in a single groove have yielded excellent results

a cross-section of this type of ring. Scuff resistance of this ring type in 1/4-in. width is comparable with that of 3/32-in. width rings. The same technique is applied to chrome-plated rings when extreme scuff resistance is required.

Locating the top ring on the piston also is an important consideration as regards scuffing tendencies. When the piston is at the top of the stroke, the top ring should not travel beyond the end of the water jacket so that the top ring will not have to operate in excessively hot cylinder areas.

Locating the top ring well down on the piston is advantageous too. A wide top land protects the ring from direct effects of combustion and reduces its operating temperature. The top ring also must be well supported by a strong second land if it is to do a good sealing job and enjoy a low wear rate. For a rule of thumb, 0.20 in. per in. of cylinder diameter for top lands and 0.05 in. per in. for second lands will provide adequate land widths.

Distribution of space on any piston always is a compromise which must be made for each individual engine. In recent years the trend to fewer compression rings in diesels has somewhat simplified the matter. Many diesels are performing excellently with three compression rings and several have been very satisfactorily sealed experimentally with only two rings.

Another space-saving device on which several engine builders currently are doing considerable work consists of using two oil rings in a common groove. Such an arrangement is shown in Fig. 8. Experimental results have been excellent, although not enough test time has been accumulated by any of those working on this configuration to make any predictions as to durability.

Discussion

Wear Reduction Depends on Cost

Excerpts fom discussion

by D. A. Paull

Chief Metallurgical Engineer

and Stuart Nixon

Research Engineer
Sealed Power Corp.

Basically, wear is a function of cost. Its reduction or prevention must balance the cost of the method used in achieving that point. Wear can be and is tolerated where its elimination would increase the cost per horsepower or ton mile.

For example, take a case of delivery trucks where the mileage is low per year, but the wear rate is high due to low temperature operating conditions causing sludging in the winter time. To control this oil condition would cost more than it would be to let the wear take place and overhaul the engine at certain mileage intervals. Or take the case of truck tractors. Some operators have found that it is cheaper to overload a low-cost, high-production engine, and replace it at intervals, than it is to use a larger, higher cost tractor truck.

Generally, the reduction of wear involves the use of a premium product and this point is satisfactory until the price factor comes into consideration along with the sales appeal. As an example, think how the wear picture would be changed on certain vehicles if all the chrome on the trim were put inside the engine on the rings where it will be some good, compare the costs, then look at the sales appeal. We believe this indicates the delicate balance existing between wear, cost, and ultimate sales appeal.

Numerous Factors Govern Ring Design

Excerpts from discussion

by M. R. Bennett

Chief Engineer, Product Engineering,
Industrial Power Engineering Department,
International Harvester Co.

Studies of piston-ring design must include consideration of the amount of foreign material induced into the system, fuel and lubricant combinations, speed and load factors, and operating temperatures.

Rapid rates of wear are desirable during the early hours of engine operation, to permit realization of optimum oil control characteristics, but once satisfactory control of oil consumption is attained, a minimum rate of mechanical wear is required in the interests of long engine life. Here again, we encounter an interesting paradox. The realiza-

tion of these wear rate patterns dictates the introduction of abrasive materials in the intake air at one point in engine life and deplores such additions at all other times.

This varying rate of optimum wear has been responsible for careful selection in the finishes secured in machining cylinder sleeves and ring wearing surfaces. Realization of super finishes at these contracting elements has always presented problems of high initial oil consumption, often extended for considerable operating periods.

Some of our engine tests have indicated that ring life with respect to mechanical wear is the limiting factor with regard to the lower viscosities in crankcase lubricants. We have experienced very early ring failures under such conditions and understand that other investigators have had similar results.

Our experiences with regard to light load, low ambient temperature operation of diesel engines suggest that the exact reverse of Brenneke's high wear rate may occur under these conditions. Where water jacket temperatures in the 120 to 140 F range obtain, and in fact, often result from low engine output requirements, we sometimes experience oil loss at the exhaust with high consumption rates. Inspection of piston rings with several hundred hours of service in such conditions will reveal almost no wear or even abrasion of the high sections of the finish patterns on rings and sleeves. I submit that the divergence of these results may possibly be attributed to the compatibility characteristics of the fuels and oils involved in the operations.

Brenneke confines his remarks on piston ring abrasion largely to compression rings. Some of our test engines, on the other hand, have shown high rates of wear at the lower, or oil control units, apparently as a result of contamination of the crankcase lubricant by abrasive materials.

With reference to the application or arrangement of piston rings to produce optimum life characteristics of the piston and sleeve assemblies, we have found that at higher engine outputs, oil control rings must be so selected and located on the piston as to permit generous lubrication of the piston skirts.

Spots Differences In Liner Materials

Excerpts from discussion

by W. J. Pelizzoni

International-Plainfield Motor Co.

With regard to the liner material problem, the interdendritic type of graphite always has shown incipient scuffing tendencies, which normally never appear with the flake type of graphite, assuming all other conditions equal.

Liner and ring wear always has been a problem with the former type of sleeve. Despite the general scuffing tendencies, we have noted in several engines run about 100,000 miles—that the end gap increase of the chrome-plated top compression ring was less than that for the second and even the third compression ring.

We don't believe that any fixed theory can be applied to all engines because each has its own characteristics which must be dealt with individually.

Higher outputs and increased efficiencies require a thorough study of frictional losses since the addition or elimination of compression rings will directly affect the drag. It was generally felt that heavy-duty engines would require the use of more compression rings in the interests of longer life and safety; but improved ring designs, materials, and surface treatments have demonstrated such good qualities that use of fewer compression rings becomes very tempting.

Liner Wear Linked To Metal Structure

Excerpts from discussion

by Paul S. Lane

Director of Research
Muskegon Piston Ring Co.

I am particularly interested in Brenneke's statement that he has observed a difference of as much as 10 to 1 in the rate of wear of two types of cylinder liners. One gave a wear rate of 0.0001 in. per 1000 miles, the other a wear rate of 0.001 in. per 1000 miles. He reports that the "good wearing" material was "gray cast" iron, the "poor wearing" liner "chill cast" iron, of essentially similar chemical composition. What about relative hardness and heat-treatments of the two irons?

These wide differences in the rate of wear of irons due to structural differences have been frequently observed and reported previously, and I think we can accept the fact that bore or liner metal structures are of considerable importance in determining engine life and durability. It is a problem with liners, and an even more complex problem with multicylinder block castings.

The metal structure in any gray iron casting is determined largely by the "cooling rate," which is in turn a function of "mass" or cross-section. Hence engine designers should recognize this fact and strive to keep metal sections equal as far as is possible. This should be done for best metal structure as well as for improved cooling and bore distortion.

Reports on Ring Width And Water Temperature

Excerpts from discussion

by Ralph L. Boyer

Cooper-Bessemer Corp.

We of the larger engine industry are interested in what Brenneke has to say about water temperatures and in fact are a little surprised to see him speak of 160 F as being a satisfactory level. We are learning that even on very large engines we apparently gain by going still higher in water and oil temperatures. This seems to be particularly true with the modern, highly detergent lubricating oil.

Most of the data presented by Brenneke are confirmed in the performance of large engines. In one case only are

we compelled to question his report, that being in connection with the width of compression rings. He states that wide rings are desirable from the standpoint of abrasive wear resistance, while narrow rings are desirable for scuff resistance. The experience in large engines seems definitely to indicate that narrow rings are desirable from all angles.

Three Piston Design Tips For Improved Oil Control

Excerpts from discussion

by H. G. Braendel

Chief Engineer
Wilkening Mfg. Co.

The piston should be designed to make the functioning of the oil ring as easy as possible. This together with an oil ring of just enough unit pressure to meter the right amount of oil to the oil ring will yield extremely long life and very low ring and cylinder wear.

Just how the piston can be made to help is shown in Fig. 9, a sketch of a four-cycle diesel piston. A single oil ring is used just below the compression ring belt. This will be adequate if the following details are observed in design of the piston:

1. The bottom of the skirt is left sharp. This part of the piston has the ability to control as much oil as an additional oil control ring provided the piston is fitted reasonably closely and this edge is left as sharp as machining will permit. An angle less than 90 deg would be preferable to a right angle at this point. In case of some large pistons, where handling might damage this sharp edge, a very small undercut as shown on the sketch will protect this edge from being damaged.

In most present day engines the specification of this detail is neglected and in many cases left to the shop's disposition whether to leave it relatively sharp or rounded off. I have found that most good old-time machinists who build the larger engines have taken great pride in providing this bottom edge with a generous radius. The difference in oil control is considerable. Contrary to the ring (which depends upon its tension to maintain contact with the cylinder wall and, consequently, will collapse due to the hydro-dynamic pressure built up by excessive accumulations of oil), the piston skirt will strip the excess oil without collapsing.

2. The oil control ring groove is provided with abundant drainage for both lands of the oil control ring. In this case the very simple expedient of providing an undercut and drilling the drain back holes with their center lines coinciding with the lower plane of the oil ring groove has made it possible to provide this drainage with a single row of drain back holes. The holes are, of course, drilled prior to grooving. It is very essential that the lower as well as the upper cylinder contacting lands of the oil ring are provided with drainage.

This again is a small detail often overlooked but easily incorporated, which greatly improves the oil control ability of the installation. It makes it possible to design the oil control ring without resorting to narrow lands and ex-

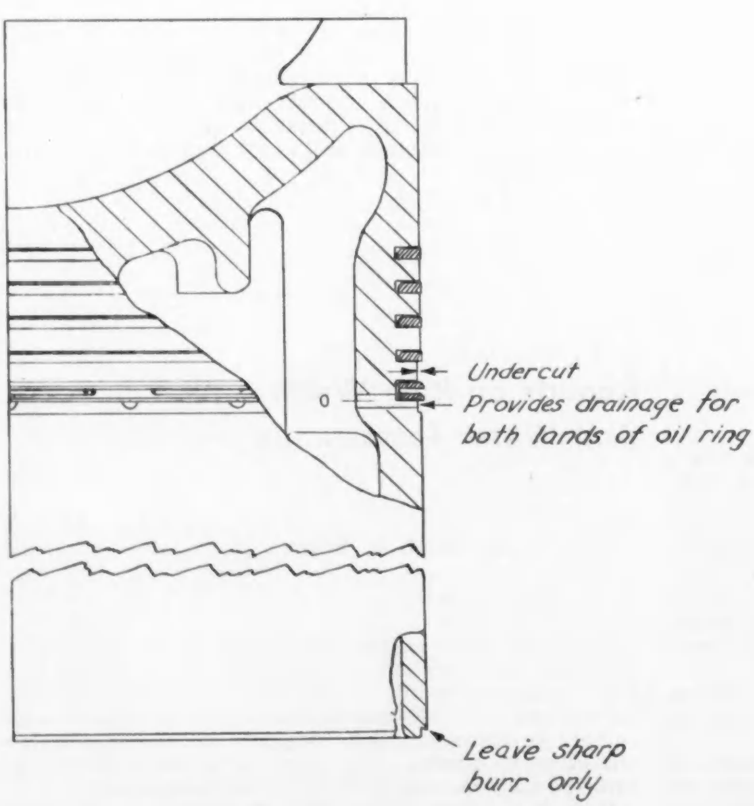

Fig. 9—By making the three modifications shown in this four-cycle diesel engine piston, the piston can enhance oil control. The changes are: (1) sharp edge on bottom of piston skirt, (2) Drain-back holes designed to give adequate drainage for oil-control ring lands, and (3) undercut on land between oil control ring and lowest compression ring

tremely high ring tensions and, therefore, results in a longer lived installation.

3. Just above the oil ring is another very simple detail which will result in considerable improvement of the oil control ability of the assembly. The compression rings in a properly designed ring combination must control the oil which must be metered to them to provide for their proper lubrication. To determine the degree of the oil control action of the compression rings it is only necessary to install the top compression rings up-side-down if they are of the more up-to-date taper faced or twisted type.

By this simple change in direction of the top compression ring the oil consumed by the engine will many times be in the order of 2 to 4 times as high as when these rings are installed properly with the lower edge contacting the cylinder walls initially. Since the compression rings are such an important factor in the oil control of the installation, any design detail on the part of the piston which will make this function easier will immediately result in a large improvement in oil control.

On this sketch you will note an undercut of approximately 25% the radial thickness of the ring on the land between the oil control ring and the lowest compression ring. This undercut provides a reservoir space for the oil scraped on the down stroke by the lowest compression ring. On each subsequent up stroke this oil may flow back to the inside of the piston through the side clearance of the oil ring. This small detail alone can be responsible for an improvement in oil control of as much as 50%. In one actual experience, the improvement made by it amounted close to 100%.

By incorporating these seemingly insignificant design changes in the piston the oil control ability of an installation may be improved to such an unexpected extent that either fewer oil rings or rings with wider contacting lands employing lower unit pressures can be employed. This results in lower friction and longer ring life because the wide lands with lower pressures will, of course, wear considerably less.

Proposed Formula Compares Specific Oil Consumption

Excerpts from discussion

by A. W. Pope, Jr.

Waukesha Motor Co.

Since oil consumption rate is a factor in preventing top ring scuffing and wear, it is necessary to have a scale of measurement for designating oil consumption rate. We have never found any of the conventional methods of designating oil consumption rate to give us a good specific figure which would permit comparing cylinders of different sizes operating at various speeds and loads. We, therefore, have adopted a method of expressing specific oil consumption rate based on the swept cylinder displacement.

We assume an engine's oil consumption will be in proportion to the swept piston displacement. The constant in the formula was selected to make the specific oil consumption rate for a typical passenger car engine to be the same as its actual consumption rate. The formula is:

$$\text{Specific Hours per Qt} = \text{Actual Hours per Qt} \times \frac{\text{rpm} \times \text{Displacement}}{500{,}000}$$

A 200-cu in. engine operating at 2500 rpm (50 mph), consuming oil at the rate of 1000 miles per quart, would have an actual consumption rate of 20 hr per qt, and by the above formula the specific oil consumption would be the same. Therefore, 20 specific hours per quart oil consumption rate on an engine is considered a normal low consumption rate.

Finds Microstructure Related to Ring Wear

Excerpts from discussion

by L. D. Thompson

Beloit Works
Fairbanks, Morse & Co.

We are particularly pleased to hear another major piston ring manufacturer stressing the importance of microstructure as correlated with actual long-time wear experience.

In a large number of wear tests, we found piston-ring wear to be exceedingly sensitive to microstructure and more important the microstructure of a "batch" of rings supposedly the same, varies quite radically. In fact, in our studies of piston ring wear, we found it necessary a number of years ago to catalogue ring microstructure as well as other pertinent data such as chemical analysis, physical dimensions, tension, circularity and so forth.

We got the microstructure by sectioning each ring after the test. In nearly every case of multicylinder wear testing where we found a marked variation in one ring's wear from the others, or average, we also found a marked difference in microstructure, even though they were supposed to be the same.

Notes Strange Wear With Chrome Liners

Excerpts from discussion

by D. J. Cummins

Cummins Engine Co., Inc.

A phenomenon (which has not been satisfactorily explained) which illustrates the effect of corrosion and abrasive wear, has been experienced on chrome-plated liners.

Chrome-plated liners show the maximum wear at the bottom of the ring travel. This has been confirmed by split tests in engines in the field—engines having three cylinders with chrome liners and three cylinders of cast-iron liners, wherein high wear was found at the top of the liner in the cast-iron liners and high wear at the bottom of the liners in the chrome-plated liners. This cause of the wear at the bottom of the chrome liner is not known, but might be accounted for by the lower temperature in that zone. Abrasive wear on cylinder liners shows up as rapid wear at the top of the ring travel.

In known cases of high dust concentration with chrome liners, a pattern showns up where there is high wear at the top of the chrome liners, characteristic of abrasive wear, and a second area of high wear, which is characteristic of the chrome liner at the lower end of the ring travel.

EXCERPTS FROM PAPER* BY

R. C. Henshaw

Manager, Product and Sales Engineering Department

L. Wallerstein, Jr.

Supervisor of Engineering Research Department

and S. J. Zand

Vice-President in charge of Engineering
LORD MFG. CO.

ALUMINUM Airplane

BY substituting aluminum forgings for steel, weight of the flexible engine suspension for the Pratt & Whitney R-4360 engine was reduced from 134 to 71.5 lb—a saving of 250 lb on a four engine airplane. Applying both results from test work and certain design principles made it possible to get superior endurance life from these highly-stressed aluminum alloy aircraft components.

Mounting Described

A flexible mounting system as used on the R-4360 is composed of two basic elements (see Fig. 1): (a) a flexible core consisting of an assembly of synthetic or natural rubbers bonded to a supporting metal core fastened to the engine mounting ring; (b) a housing for the core shaped in such a way as to allow relative motions between the two parts.

The R-14360 engine, due to its substantial length, required special consideration in attaching the housing to the engine. The engine manufacturers found it desirable to take the major portion of the weight and thrust directly through the crankcase, while the blower and accessory drive housing would take care of the torque loads. The mounting designer had no alternative but to provide a pedestal (a) at the crankcase Fig. 2, a housing (b) for the flexible core (c) (attachable to the engine mount ring), and a link (d) with suitable pins (e_1), (e_2), forming a bridge between (a) and (b).

The relative motion due to vibration of the engine as a whole in relation to the airframe will be taken by the rubber core. There is also motion due to the vibration of the crankcase in relation to the blower housing which must be accommodated by the link and its associated parts. Thus, in addition to the static stresses, the link and its adjacent parts will be subject to cyclic stresses and their fatigue life or endurance limit may be the critical point in this design.

Common structures are generally judged only by

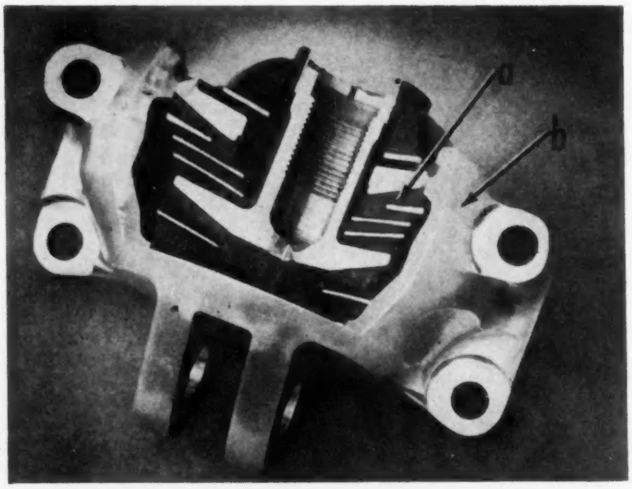

Fig. 1—Three-quarter section of the flexible core (a) and housing (b) of a flexible suspension

two criteria: static strength and stiffness. In lightweight—particularly aluminum alloy—designs, the realization at the earliest phase of the layout that fatigue strength, too, may be of significance is important. Only then can the designer, manufacturer, inspector, and user be warned to look out for notches, nicks, keyways, oil holes, screw threads, scratches, rough surfaces, sharp changes in section, inadequate fillets and radii, tool marks, and so forth—all contributing to low fatigue life.

When designing for long fatigue life and, at the same time, aiming at the lowest weight, it is most important to know exactly the magnitude of the dynamic and static loads. The value of the latter is easily obtained; the magnitude of the former cannot be calculated in most cases and must be measured.

In many instances data from torque stands are used; but even these must be employed with caution. Torque stands are structurally much stiffer than airplane structures and this stiffness, combined with the elastic characteristics of the whole

* Paper "Fatigue Life of Aircraft Engine Mounting Components," was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Does Steel's Job in Engine Mounting

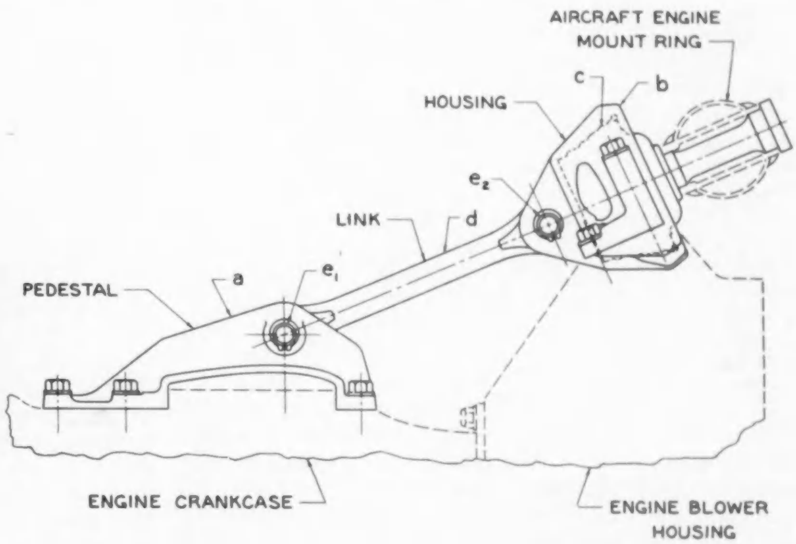

Fig. 2—Schematic drawing showing the elements of the light-weight suspension used on the Pratt & Whitney 4360 engine. (a) is the pedestal bolted to the crankcase; (b) the housing mounted on the blower housing; (c) the flexible core attached to the engine mount ring; (d) the link; and (e_1) and (e_2) pins holding (a) and (b) together

mounting system, may play an important role in the overall stress distribution.

A safe method is to fly the airplane and make actual measurements varying the engine power from minimum cruising to take-off. Such measurements can be made with established techniques using strain gauges and multi-channel recorders. The loads thus measured can be duplicated in the laboratory by using suitable exciters and "SN" curves plotted for the given parts.

An "SN" curve is a graphical representation of the relation of the number of cycles (abscissa) to the applied static and dynamic stress. To get the trend of the curve it is a common practice to start the tests at much higher loads than the actual ones and mark the number of cycles to failure. For stresses below these values, where the curve becomes parallel or nearly so to the abscissa, infinite fatigue life may be assumed.

Evaluation of the effects of repeated stress on the mounting can be undertaken only after a stress analysis based on static loading is accomplished. The conditions under which this suspension had to perform were: take-off loads in the direction of tension 4700 lb; in the direction of torque (shear load 1740 lb. Further, it was mandatory that parts should not fail at 12 g + 1.5 power load, which translates itself into the following final design load figures: 33,500 lb tension and 3620 lb shear.

Link Analysis

The link analysis is of particular interest since this part proved later to be the critical one with respect to its endurance life. Stresses in the link eye were first calculated for a representative test condition using the method of Timoshenko's "Theory of Elasticity." The load chosen was composed of a static force of 4700 lb (calculated take-off value) with a superimposed alternating force of ± 1500 lb, which was roughly one and one-half times the measured vibratory load. The resultant alternating stress had a maximum value of 37,200 psi and a minimum value of 19,300 psi.

Using these figures, a fatigue life of five hundred

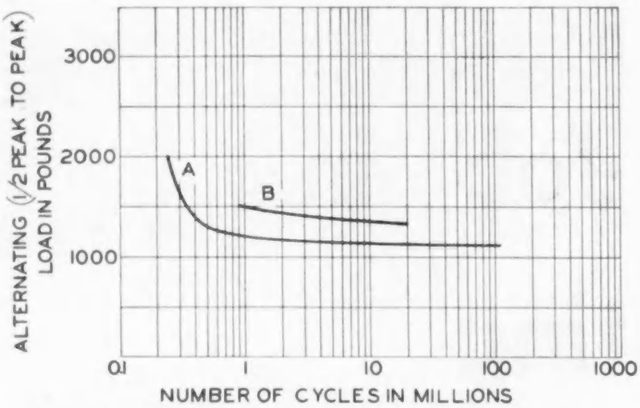

Fig. 3—Plotted here are the endurance of the original link design (curve A) and that of a revised design (curve B). They represent Designs A and B in Fig. 4

million cycles can be expected from this design. This figure is obtained by extrapolating the table given on p. 52 of "Strength of Metal Elements," ANC-5a (Munitions Board Publication). Early tests, however, showed only a small portion of the expected 500 million cycles and it was obvious that for some reason, at that time unknown, the full endurance strength of the part was not being realized.

In addition to the above calculations the parts were "stress coated," subjected to static loads and where concentrated stresses were found, strain gages were placed, the stresses measured and design changes made to secure as even a stress distribution as possible.

Test Program

The approach which the authors followed under Air Materiel Command guidance and with the cooperation of the Fairchild Co. was as follows:

(a) Fly the airplane under conditions of cruising and record the loads at the different critical points, using dynamic strain gages. An a-c bridge circuit proved to be very satisfactory.

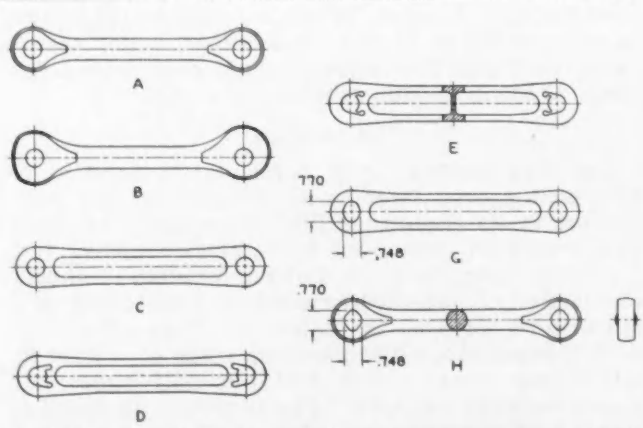

Fig. 4—Evolution of the link design. Design H was the one finally selected

(b) Fly the airplane under take-off conditions and record as in (a).

(c) Tabulate and compare results with the ones obtained by AMC on torque stands.

(d) Make a Fourier (harmonic) analysis of the records, using the graphical method of Manley, Runge or Zand and determine which orders of vibration are predominant. In this case they were first, second, and two and one-half engine orders. Second order and an engine speed of 2500 rpm were taken as representative values, giving a rate of 5000 cpm for calculating the number of vibration cycles generated in any specific period of time.

(e) Conduct fatigue tests to establish the SN curve, and from this determine the ability of the mounting to endure:

(1) 200 hr, or 60 million cycles, at take-off load, and

(2) 4000 hr, or 1200 million cycles, at cruising load.

Naturally, to determine each point on the endurance curve with the least statistical scatter, several specimens have to be tested under identical conditions.

Among the items of equipment used in the test program was a laboratory exciter capable of generating static and dynamic loads equal to, and exceeding, those encountered in service. Each link with its strain gage was calibrated before the fatigue test so that gage output could be used to measure the test load. An automatic monitor supervised the test without personnel present.

Test Results

An initial series of tests on 26 assemblies disclosed the following facts and prompted the subsequent actions:

(a) The original design had sufficient endurance strength for the intended service, but a reserve strength of only 10% for take-off conditions. The critical element was the link, and the endurance established is shown by Curve A of Fig. 3. A strengthened link (link B, Fig. 4) was then designed, the unsymmetrical configuration being adopted due to lack of space. This improved the endurance life as shown by Curve B of Fig. 3.

(b) Although both housings and pedestals had higher endurance strengths than the link, failures at higher than take-off loads in these parts pointed to possible improvements, which were made. The original housing lugs cracked as shown by Fig. 5; the same picture shows the redesigned lug. This new design not only employed less metal, but eliminated completely all failures. Fig. 6 shows a typical pedestal failure. By increasing the radius at the point marked with the arrow and by improving the blending of surfaces, the part was so strengthened that no further failures were experienced. The strength at the clevis pin hole was also improved by refinements as shown in Fig. 7.

Following the initial series of tests, further improvement in link endurance was sought through redesign, resulting in the H-section link shown in Fig. 4D. It was suspected that the stress at the hole was higher then given by calculation since life predicted by theroetical analysis was not secured. By removing metal at the inside of the link and providing restraint toward the periphery of the hole, stress

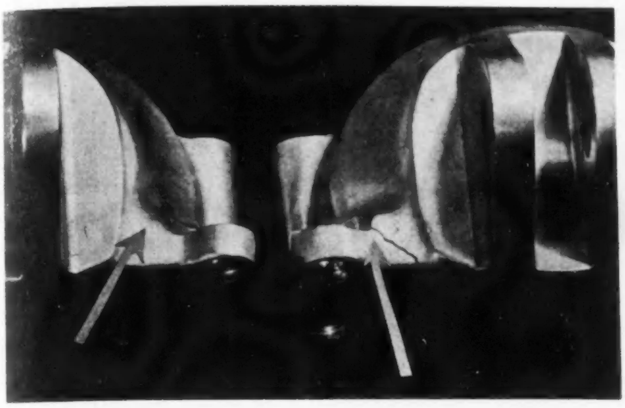

Fig. 5—Housing lug before (right) and after redesign (left) for greater endurance life. Note the crack and sharp corner next to the right-hand arrow and smooth blending in the redesigned part

concentration was removed from the edge of the opening.

Results with experimental links were highly satisfactory. However, when the first production quantity of the H-links was put through a similar test, their endurance strength was only marginal.

While seeking to explain this inconsistency, further modifications of the H-link were made as shown by Fig. 4E. The purpose of the cut-outs was to reduce to an absolute minimum stress at the hole edge. Improvement over previous results was achieved and the design was then discussed with AMC metallurgists and specialists in structures.

The theory was advanced that improvement in stress pattern was only partially responsible for the excellent performance, and that the relief had also served to prevent fretting corrosion at the points of concentrated stress.

Fretting Corrosion

Fretting corrosion is a phenomenon encountered where clamping stresses under a collar or in a press-fit produce servere stress raisers. The roughening or galling of the surface in such designs is a contributory factor to lower fatigue life. Normally on such joints, the clearance between mating parts is extremely small, in the order of 0.0001 to 0.001 in.; but even this small play gives rise to galling and tearing off of tiny metallic particles which sift out and immediately become oxidized.

The steel particles come out as a fine, reddish powder, or rust. (The common British name for this phenomenon is "cocoa" and the Germans called it "blood"). In the case of aluminum, the oxides (very abrasive by nature) appear as a fine powder and imbed themselves in the layer underneath as a series of tiny wedges. The usual preventatives, such as use of fiber inserts, were not possible because of lack of space and so the idea of a relief where the pin is subject to highest stresses was finally adopted. See Fig. 4G.

Controlled tests proved beyond doubt that anodizing of parts subject to high dynamic stresses lowered the endurance limit materially. All production links were anodized by the sulfuric acid process.

The only promising solution was to revert to

Fig. 6—At left is shown the transition radius between a vertical and horizontal surface on the pedestal before redesign. Greatly increasing this radius, as shown at right, improved endurance life

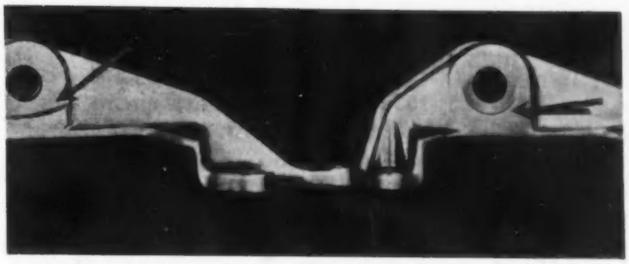

Fig. 7—Before-and-after design treatment of the clevis pin hole in the pedestal are shown here, with the improved design at left

chromic acid anodizing, which has not been used extensively since the mid-thirties. While the absolute corrosion resistance of chromic anodizing as measured by the salt spray test—a purely arbitrary specification—is not as good as sulfuric anodizing, the degree of protection offered by chromic anodizing is high enough so that parts thus treated will outlast the airplane.

The information gathered resulted in the design now in use of a link, Fig. 4H, incorporating anti-fretting corrosion reliefs and chromic acid anodizing. Tests on this link have produced the endurance strength curve shown on Fig. 8. The curve for the original link is shown for comparison.

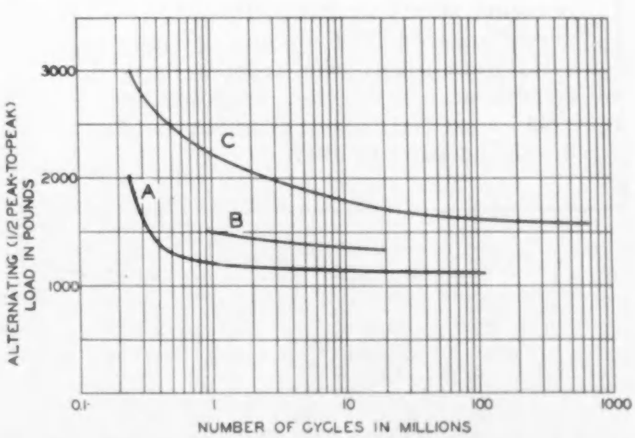

Fig. 8—Endurance strength of the link design in Fig. 4H anodized with chromic acid (curve C), as compared with that of link designs in Fig. 4A (curve A) and Fig. 4B (curve B)

Excerpts from

SYMPOSIUM* on

Between 1930 and 1940, most car manufacturers switched from spiral bevel to hypoid rear axle gears. To insure that gear oils met the stiffer requirements of hypoid gears, manufacturers established such performance tests as the General Motors Shock and High-Speed Tests, Chrysler High-Speed and Mountain Truck Tests, and the Gleason four-square dynamometer test . . . and such laboratory screening tests as the SAE Extreme-Pressure Machine and Almen Moisture Corrosion Tests.

Cooperative examination of all gear oil tests during World War II resulted in establishment of Army Specification 2-105 for gear lubricants and, more recently, the current 2-105B. Among the tests which an oil must pass to qualify under this specification are the CRC L-19 and L-20 axle tests for load-carrying ability, the L-17 bench test (which uses the SAE Extreme-Pressure Machine) for load-carrying ability, and the Almen Moisture Corrosion Test. Some of these tests were taken over from Federal Specification VV-L-761, proposed in 1942, modified several times, and finally adopted in 1947.

For Performance

—W. J. Backoff, N. D. Williams, and K. Boldt
THE PURE OIL CO.

WE have found that the 2-105B qualification tests do not cover the full range of requirements for all types of service. From the several test procedures we have investigated, we would add the Chrysler Mountain Truck, the General Motors Shock, and The Pure Oil Co. High Speed Tests to the L-19 and L-20 tests in order to cover the most severe types of service.

We believe that three levels of gear lubricant quality can be established to cover the full range of service requirements. The performance tests which can be used to define these levels are:

Service	Performance Tests
Service Station Refill	L-19 and L-20
Factory Fill	L-19, L-20, GM Shock, and Pure Oil High Speed
Heavy-Duty Truck	L-19, L-20, and Mountain Truck

A fourth lubricant may be used which would cover the requirements of all three types and thus approach a truly all-purpose automotive differential gear lubricant. Usually, however, it will be more economical to make single types for specific applications.

The L-19 and L-20 tests are common to all type lubricants and hence define the minimum quality level. (The L-19 test is a modification and combination of passenger car shock and high-speed test procedures, and is generally classified as a high-speed, low-torque test. A standard Chevrolet passenger car is used for the L-19 test either on the road or on a chassis dynamometer. For the L-20 test, the Gleason four-square dynamometer or equivalent laboratory equipment is used, and this test may be classified as a low-speed, high-torque test.)

A 6000-mile Mountain Truck Test has been used in place of the usual 3000-mile Test for evaluating several lubricants to investigate a possible increased severity. The aim was to obtain mechanical gear failure to avoid evaluating small differences in de-

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* Papers "Performance Testing of Gear Lubricants" by Backoff, Williams, and Boldt; "Laboratory Wear Tests With Automotive Gear Lubricants" by McKee, Swindells, White, and Mountjoy; and "Moisture Corrosion Test for 2-105B Gear Lubricants" by Sands were presented at SAE National Fuels and Lubricants Meeting, St. Louis, Mo., Nov. 4, 1949. (Each of these papers is available in full from SAE Special Publications Department. Price 25¢ each to members, 50¢ each to nonmembers.)

Testing Gear Oils

For Wear Prevention

—S. A. McKee, J. F. Swindells, H. S. White, and W. Mountjoy

NATIONAL BUREAU OF STANDARDS

THE SAE Extreme-Pressure Lubricant Testing Machine, with modified lubricating system, can measure rate of wear with various gear lubricants under conditions simulating high torque and low speed.

(In the past, most of the work with the SAE Machine has been confined to the testing of the load-carrying capacity of gear lubricants under certain fixed operating conditions which simulate high speed and shock load.)

The machine is particularly adaptable for wear tests in that the test specimens are of such size and shape that accurate indications of wear may be obtained by determinations of loss in weight. Also, any wear that occurs on the test cups does not materially affect the area of contact under a given load. On the other hand, the method of lubricating the test surfaces is not especially suitable for long-time tests. It seemed advisable to modify the machine in this respect.

Primary objective in modifying the lubricating system was long-time operation. It was felt desirable also to provide better temperature control of the upper test cup. The lower test cup is supported in a small oil box with the oil level about half way up the cup. Lubrication between the two cups is effected by the oil carried up by the lower cup as it rotates. Since only the lower cup is cooled by immersion in the oil bath, the upper cup runs at a considerably higher temperature. This is usually quite noticeable in the load-carrying capacity tests. For this reason, it was decided to use an additional oil reservoir of larger capacity with a circulating system for applying a stream of oil to the upper test cup.

The design of the SAE Machine is such that one of the major problems in the development of an oil circulating system was the prevention of excessive oil leakage around the test cups and oil box. The system in present use is reasonably satisfactory in this respect.

The arrangement of this circulating system is

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For Moisture Corrosion

—T. P. Sands

MONSANTO CHEMICAL CO.

IT isn't the relative humidity, it's the absolute humidity that must be uniform to maintain accuracy of the Almen Pin Moisture Test. And the significance of the Almen test—even of accurate results—is still questionable.

Studies of a moisture corrosion test run on an Almen machine were renewed in 1948 because test results on the CRC Designation L-21 axle rusting test were generally conceded to be nonreproducible. At first, several laboratories independently began a study of the possible variables in the Almen Pin Moisture Test. In June of 1949 the CRC Gear Oil Group formed a Panel to study the variables in this moisture corrosion test as well as the corrosion problem in general. This CRC work, having just gotten under way, has produced no cooperative results as yet, but the author's laboratory has made some interesting discoveries in its preliminary investigation of this corrosion test.

Essentially, the Almen Pin Moisture Corrosion Test consists of running a standard Almen machine, without water added to the lubricant, with an arm load sufficient to give an oil sump temperature of 200 F minimum. The test time is 25 min. Upon completion of this portion of the test, the pin and bushings are removed from the Almen machine and allowed to drain, without cleaning, in a Gooch crucible for 30 min at a temperature of 180 F. The parts are then removed and placed under a bell jar along with a beaker of water. The parts are left in the bell jar at ambient temperature for 24 hr and are then inspected for rusting. The 2-105B requirements for this test allow only a very small amount of rusting on the pin or bushings.

Since it was suspected that the relative humidity would not be as significant as the absolute humidity, a series of tests was run to study this variable. At the same time the effect of varying the oil temperature during the Almen test was studied. Fig. 4 illustrates the scattering of ratings with a bell jar temperature varying from approximately 75 to 85 F and the oil sump temperature varying from 190 to

Turn to page 50

For Performance . . . Continued from p. 46—Column 2

gree of rippling of surfaces which occurs when reasonably satisfactory lubricants are being compared. This approach was only reasonably successful, and another change in test technique, which proved more satisfactory, has been adopted.

It was felt that a change to the Dodge 2-ton engine in the 1½-ton chassis would reduce operating difficulties experienced on the severe test course used for this work. At first glance the small increase in maximum horsepower available in going to the larger engine seemed insignificant, and without too careful a study of gear loading the change was made in our vehicles. However, the first 3000-mile test made after the change proved we had a much more severe test and lubricants which were previously satisfactory moved into the failure class.

Since our Laboratory is located near Chicago and this Mountain Test course is in Pennsylvania and Maryland, we tried to obtain a satisfactory substitute for the mountain testing in the Chicago area. These attempts have been only moderately successful, but others who might wish to carry on this type of work may profit from our experiences.

We increased the gross vehicle weight to the maximum axle loading allowed by the States of Illinois and Wisconsin, over whose highways the vehicles operated. This loading came to 38,000 lb gross and required tractor as well as trailer load to get the maximum gross load and keep the axle loading within the limits. It was also necessary to relocate the fifth wheel to shift more weight to the front axle, since we had to keep under 18,000 lb per axle.

The Mountain test course was re-examined and the number of low-gear (first and second) operations counted for both coast and drive operation in one complete cycle of the course. From this analysis, the amount of low-gear operation for the 3000-mile mountain test was obtained. From these data, an accelerating-decelerating procedure was devised:

Vehicle: 1½-ton Dodge Tractor with 2-ton engine

Load: 38,000 lb gross

Procedure: 1. Accelerate through the gears from a stop to fourth gear.

2. Decelerate using the engine as a brake down through the gears, shifting to the next lower gear at the road speed used for up-shifting.

3. Bring vehicle to stop and repeat Steps 1 and 2 for 500 cycles (approximately 500 miles).

This procedure, although contrary to any normal truck operation, did subject the coast side of the gears to approximately the same load as found in the mountains and for the same number of times as found in 3000 miles of mountain operation. The results obtained using this procedure show some promise of approaching the mountain test severity, although the results of our limited number of tests indicate the number of cycles must be increased if reproducibility of test severity is to be obtained.

Test reproducibility appears good using this procedure, although the number of tests has been limited, and we cannot judge this factor with the same reliability as the mountain tests.

This stop-and-go procedure is not recommended until all possibilities of mountain testing have been exhausted. It is much more severe on both the mechanical operation of the equipment and on the vehicle driver.

Our experience with these qualitative road tests has shown that mineral oil stocks and additives must be closely controlled, and any change in stocks—such as viscosity range, type of crude, or refining method—must be carefully evaluated and the proper additive selected for the new combination. Any of these changes can require a complete change in additive type or concentration or both.

For Wear Prevention . . . Continued from p. 47—Column 1

shown in Fig. 1. The oil being tested is drawn from the reservoir "A" by the motor-driven pump "B" and delivered through the ¼-in. pipe "C" to the top of the upper test cup, which is covered by the special oil splash guard "D." The oil then drains to the oil box "E." This box is fitted with two ¼-in. overflow pipes "F," so located that the oil level in the box partially immerses the lower test cup. The oil from the overflows falls into open fittings in the ¾ in. drain pipe "G" and drains back to the reservoir. Also shown in the figure are thermocouples "H" in the oil box and oil reservoir, heater "J" on the oil reservoir, and auxiliary heater "K" on the delivery pipe.

A view of the test cups and oil box assembled except for the splash guards is shown in Fig. 2. The

counter-weight "L" is mounted from the oil box to counter balance the overflow pipes and the overhanging lower test-cup shaft. An oil thrower "M" is mounted on the upper test shaft as shown, and "N" is a special nut for the upper test cup (a portion of its length is a cylindrical seat for the inner oil guard, which is shown in Fig. 3). Fig. 3 shows accessory parts and changes in the oil box as follows: "P," inner oil guard which rides on upper test shaft; "R," plate sealing oil-box bearing; "S," seal for shaft at other oil-box bearing; "T," dams welded to oil box to fit outer oil guard "D;" "U," grooves in spacers on lower test shaft; "W," special drain hole in oil-box bearings.

In all tests, the upper test cup was driven at a speed of 500 rpm with a 3.4 to 1 gear ratio between the upper and lower cups. This provided a 2.4 to 1 ratio of rubbing to rolling at the contacting surfaces. The specimens used were steel Timken test cups T-48651 and in most of the tests had an average surface roughness of from 25 to 30 microin. (rms, Profilometer). A 2-qt sample of oil was used in each run. This was circulated at a rate of about 500 g per min. Using a constant oil temperature of 225 F, tests were made at constant loads of 90, 135, 180, and 225 lb (scale readings) respectively. The loading system is such that the corresponding loads on the 2-in. diameter by ½-in. test cups are 10 times the scale readings. Tests were also made at 250 F and 180 lb load. The above conditions approximate the range of conditions covered in the usual high-torque low-speed gear tests.

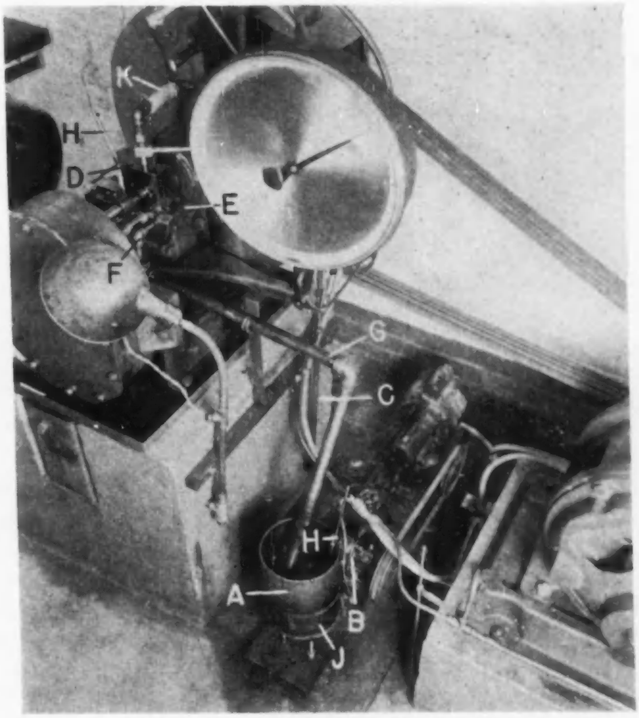


Fig. 1—SAE Machine with special oil-circulating system

The test cups were weighed before and after each period of operation during a test, the loss in weight being used as a measure of wear during the period. In the first few tests in the program, weighings were made at frequent intervals and the tests were run for as long as 75 hr. It was found, however, that representative data could be obtained by operating for about 25 hr, making weighings after operating

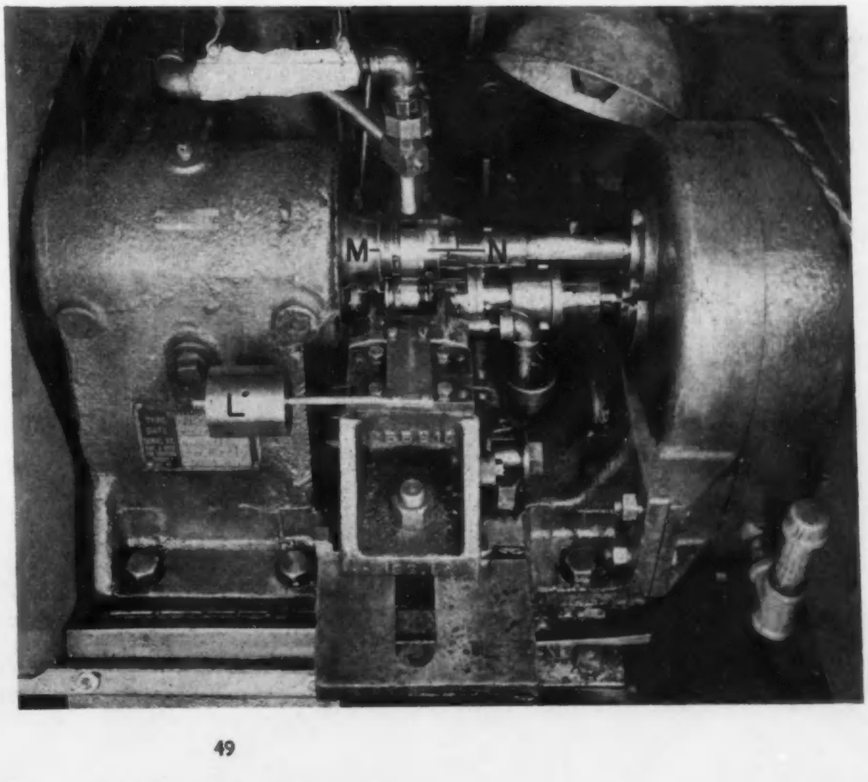


Fig. 2—Test shafts and oil-box assembly

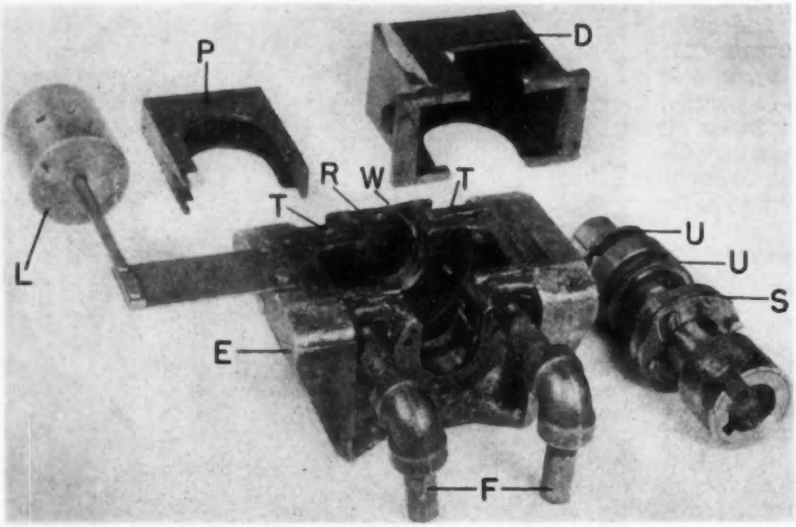


Fig. 3—Special parts and changes to oil box and lower test shaft

4, 11, 18, and 25 hr respectively. Most of the tests were run on this schedule.

Data indicate that under the conditions present there is a run-in period of high rate of wear for a few hours, after which the wear settles down to a fairly constant rate. In general, the constant rate is well established by 25 hr of operation and subsequent test runs were of that duration. The rate of wear is more significant from the standpoint of estimating gear life than the observed loss in weight for any given length of time. Initial differences in run-in wear lose their significance when long-time wear is estimated from wear rates.

Results of check runs indicate that the results are reproducible within practicable limits.

Although wear data with hypoid gears are not available for a direct comparison, it is believed that these results are in reasonable agreement with the known service performance with the lubricants tested.

The lubricants containing the more chemically active additives for withstanding higher shock load tended to show the greater wear. This is in agreement with the known service performance of some of these lubricants, particularly an active-sulfur lubricant and a nonadditive mineral oil.

In tests where the rate of wear was relatively low, the roughness of the test cups decreased in the run-in period and tended to level off in a range between 10 and 20 microin. As the rate of wear increased, there was a trend for the roughness to increase. This was especially noticeable in cases of excessive wear where there was definite "ridging" of the cups, which in some cases was beyond the range of the Profilometer.

Some study was also made of the effect of the original surface roughness of the cups on the rate of wear. Data obtained in tests with the mineral oil and a 2-105B lubricant operating at 225 F and 135 lb load using cups with original roughnesses of 14, 28, and 35 microin. (rms) indicate that the net result of operation was to bring the roughness of the cups fairly close together. Wear versus time curves show that while run-in wear tends to increase with increase in roughness, the final rate of wear is practically independent of original surface roughness over the range covered. This is of considerable importance in tests of this kind, in that comparable data may be obtained with reasonable tolerances in the surface roughness of the cups.

For Moisture Corrosion ... Continued from p. 47—Column 2

240 F. It is apparent that reproducibility was very poor and that the line could have been drawn horizontally as well as the way it was drawn. The "Rust Rating" on this slide is an arbitrarily selected rating from 10 to 0, with 10 being clean and free from rust and 0 representing very severe rusting.

Fig. 5 illustrates results of the Almen Moisture corrosion test on the same oil blend, with the oil sump temperature varying as before, but with the bell jar temperature controlled at 100 ± 3 F. It will be noted that the reproducibility is much better than in the previous figure.

Fig. 6 shows the results of further testing on the same oil blend, but with the bell jar temperature controlled at 100 ± ½ F. It will be noted that at any given oil sump temperature the reproducibility is about one half a rating number except at 230 F, where it varied from 2 to 4½.

Fig. 7 illustrates the effect of various bell jar temperatures. In each case the temperatures of 80, 95, 100, 105, and 125 F were controlled to ± ½ F. Even though the relative humidity in al cases was assumed to be 100%, the absolute humidity at 80 F versus 125 F makes the difference, with an oil sump temperature of 190, of a rust rating between 3 + and 6½. Although the general rusting conditions were more severe at the oil sump temperature of 240 F, the difference in ratings between the 80 and 125 F bell jar temperature is essentially the same at the higher oil sump temperature.

The 2-105B requirement for rusting in this test is a rating of about 8. Therefore, this particular lubricant would not be acceptable under any of the test conditions here studied. Nevertheless, the importance of controlling the bell jar temperature as well as the oil sump temperature is apparent. The range of 80 to 125 F for the bell jar temperature is within the possibilities of running the test as presently specified, since it is conceivable that 125 F could be obtained in the bell jar if it were near a window and in the sun.

As far as is known to the author, there have been no controlled field tests to determine the moisture

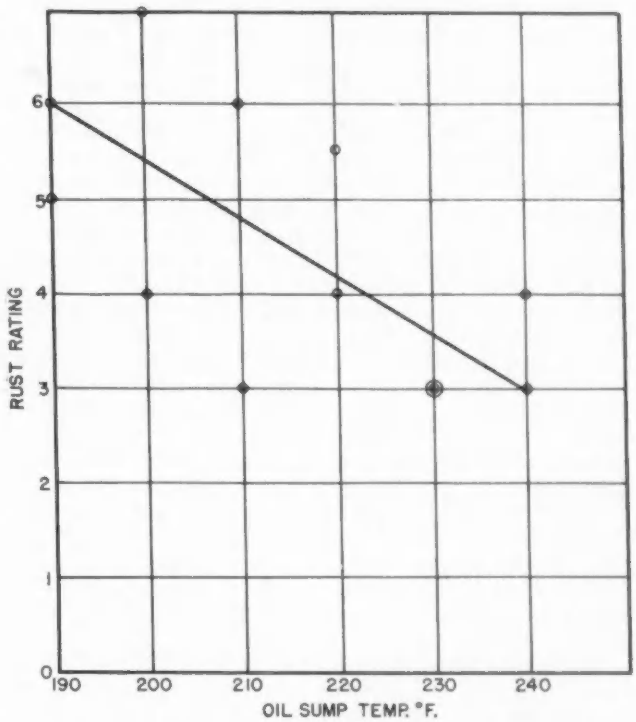


Fig. 4—Almen rust ratings on particular oil blend with bell jar temperature at various oil sump temperatures

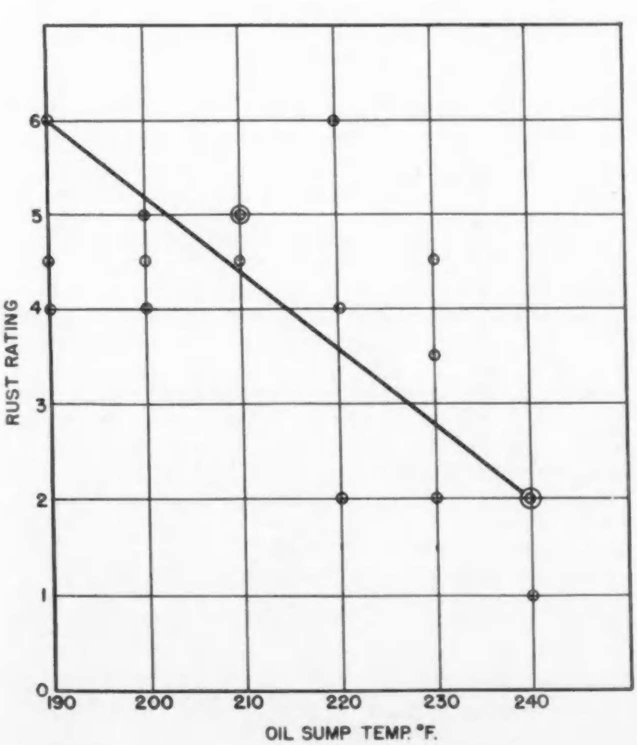


Fig. 5—Almen rust ratings with bell jar temperature controlled at 100 ± 3 F and various oil sump temperatures

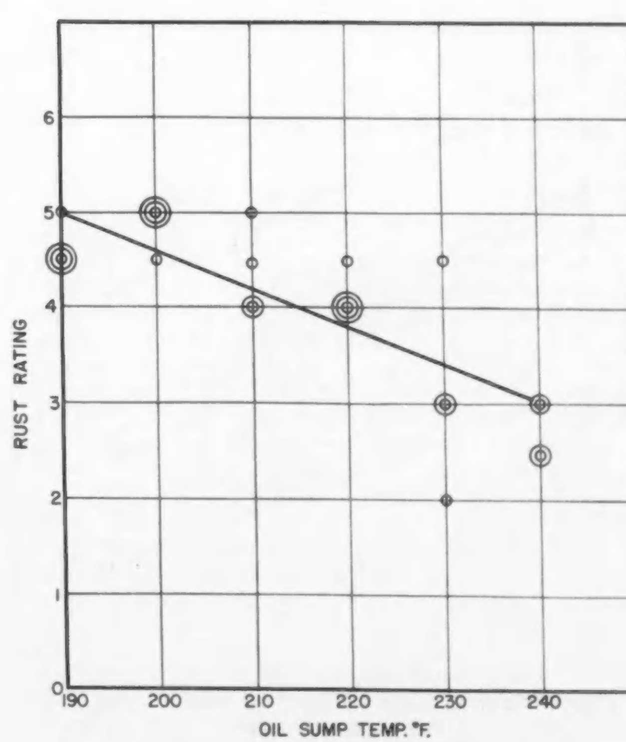


Fig. 6—Almen rust ratings with bell jar temperature controlled at 100 ± ½ F and various oil sump temperatures

corrosion protection properties of 2-105B gear lubricants. The 2-105B gear lubricants have been in use since 1946, and as far as is known the moisture-corrosion protection properties of these lubricants have been generally satisfactory.

In order to have some tie-in with field problems for this presentation, five hypoid gear lubricants, as supplied by major oil companies, were obtained from the field and subjected to the Almen corrosion test with and without control of the discussed variables. These oils represent coast-to-coast products. Oil B was specifically included because it has been reported to have allowed a few scattered cases of rusting in the field.

Fig. 8 illustrates the results of the Almen corrosion tests on these oils. Please note that Oil B gave the best ratings of those tested; Oil E gave four tests at a rating of only 3. All oils but E presumably would meet the rusting requirements of 2-105B at this date.

If Oil B had given a rating of 3 instead of Oil E it would have been quite apparent that perhaps this test did have some significance in field service, but the results obtained indicate that perhaps the correlation between this test and field service is not too good.

Therefore, work was started to investigate further these five oils in an attempt to rate them properly in the order of the indicated field experience. The first thing that was tried was to place some water in the sump at the time the test was started on the Almen machine. Preliminary results have indicated that whereas the test is made much more severe, the order of rating is not changed.

The very meager data on the field samples were given in order to illustrate that the final answer is not available at this time as to the significance of the presently used moisture corrosion test. It would seem that much more work and thought is needed on this subject.

It is always dangerous in testing of any kind to stray too far from actual service conditions, and it may well be that the Almen Pin Corrosion Test falls into the category of being a bench test which is difficult to correlate with field experience. It is hoped that after the test is made reproducible, work can be done on it in relation to actual field service.

It has been logically suggested that a moisture corrosion test might be worked out utilizing test parts as they come from the L-19 or L-20 gear tests. There are several reasons why such a suggestion seems advisable. In the first place, the ability of some gear oils to maintain a low temperature under operating conditions is different from that of others. Therefore, the gear oil which allows only a comparatively low temperature rise could conceivably be less severe on rusting. At any rate, the oil-gear system, after going through the L-19 or L-20 test, would presumably represent field service under at least one set of operating conditions. It has been proposed that after inspection of the test gears, the ring gear and pinion as well as the bearings and other parts be placed in a humidity cabinet with the absolute humidity controlled. It would seem

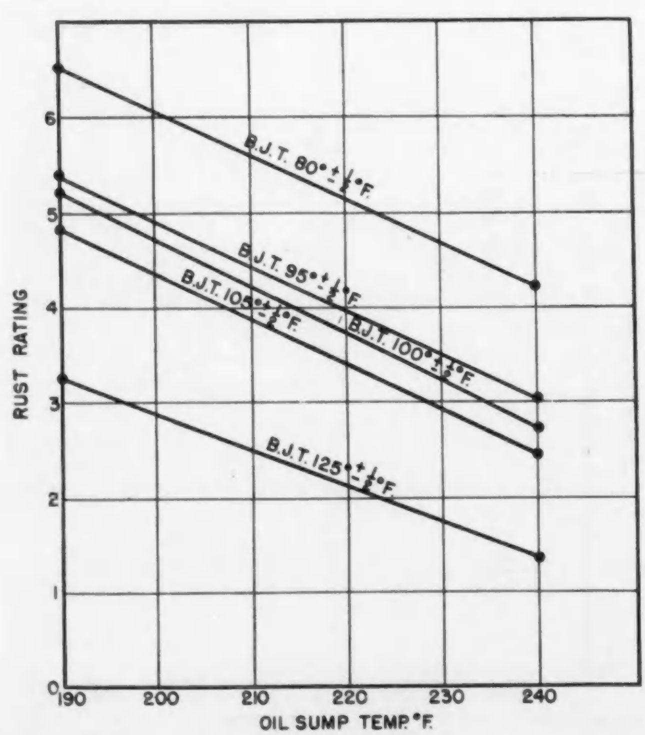


Fig. 7—Almen rust ratings at various bell jar temperatures and various oil sump temperatures

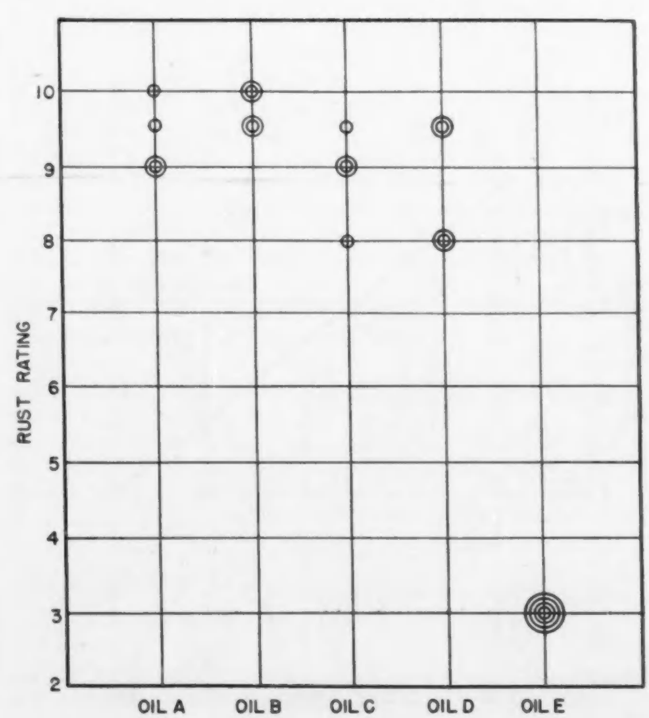


Fig. 8—Almen rust ratings on curb samples of hypoid gear oils

that such a test would more closely be related to what might happen in the field.

It would seem important that further work should be done vigorously in an attempt to determine what level of moisture-corrosion protection is required of hypoid gear lubricants, so that a completely satisfactory product will be assured from a rust protection standpoint, and also that an unnecessarily high level of protection will not result in a compromise on other desirable properties of the lubricant.

Discussion of Sands' Paper

—J. P. Stewart
Socony-Vacuum Laboratories

The reference to the possible danger of striving for an unnecessarily high level of rust protection is in effect a warning that that characteristic can be overemphasized. With that I am in agreement, and I also feel that the thought can well be amplified to include the danger of striving for protection against a rusting condition that is nonexistent in operational service through evaluating the lubricant by a test that does not reproduce conditions existing in the axle. Does the Almen Pin Corrosion Test fall into that category?

The Almen test was developed largely with lubricants of the VV-L-761 type, which could cause two types of rusting: rusting during service from water in the oil; and rusting of gears and bearings during axle overhaul, after they had been dunked in naphtha or other solvent to remove the adherent oil film and left lying around the repair shop—not a very frequent occurrence and one easily guarded against. Both types of rusting undoubtedly attended the use of the early VV-L-761 lubricants and resulted in a request from the military that an antirust agent be added to the oil. We have testimony that addition of those antirust agents eliminated in large measure the rusting difficulties then being experienced. Yet, from the Almen Pin Moisture Corrosion Test one would not have anticipated such a result. Why?

It would seem to be highly significant that the rust inhibitors employed with the VV-L-761 type lubricants were emulsifying agents in practically all cases. The mechanism by which such agents were believed to function was the suspension of the water in the form of an water-in-oil emulsion, thus preventing the water from reaching the metal surfaces. In the Almen Pin Moisture Corrosion Test, the emulsion mechanism is entirely lacking, for water does not enter the picture until the final high humidity storage period—and during that period there is no agitation whatsoever to create an emulsion with the almost nonexistent film remaining on the metal surfaces.

Thus, in this test, are we ignoring the protection afforded by the emulsifying properties of the lubricant, and are we evaluating merely that property of questionable benefit which comes into play only when the occasional careless mechanic washes off the protective oil film and allows the axle parts to lie around the shop? The service data presented by Mr. Sands, scant as it is, wherein an oil giving a very high Almen pin antirust value has ben reported as occasioning some rusting in the field while no such record attends the use of an oil giving a very low Almen antirust value, at least suggests this possibility.

Mr. Sands refers to suggestions that as an alternative to the Almen Pin Corrosion Test an axle rust test might be incorporated into or subtended to the High Speed Axle Test (CRC L-19). A number of tests of this nature have been made in our own laboratory, both with and without water added to the oil. In the former case—which is probably the more significant—after examination of the gears for evidence of scoring, 28 ml of water was added to the used oil and the axle operated under the conditions of the L-21 test for 10 min to mix thoroughly the oil and water.

In each case, after draining, the gears and bearings were placed in a cabinet in which the atmosphere was maintained fully saturated at temperatures up to and above 95 F. In no case was there any evidence of rusting or pitting of the metal surfaces over a 2-month storage period, and this with an oil that invariably gives a rating at best of not over 5 on the Almen Pin Corrosion scale. Here we would appear to have all the axle conditions conducive to rusting: gear and bearing surfaces activated by the lubricant to resist scoring during the earlier high-speed portion of the test, and a lubricant activated by the high oil temperatures attending that portion of the test, and then the axle parts exposed to a humid atmosphere.

It would seem that such results as these, coupled with past service records and those cited by Mr. Sands, lead to the thought that probably the Almen Pin Corrosion Test—at least as it is now constituted —is not evaluating the oils as the axle does and that in attempting to satisfy that test we may be leaning so far backward as to lose that nicety of balance in the lubricant which is a requisite to optimum lubrication over the entire gamut of operating conditions.

Before we finally commit ourselves to a bench test of questionable simulation and reproducibility, would it not be wise to persevere a little longer in attempting to make the axle tell us what we want to know about the rust-protection properties of the lubricant, just as we do to determine its lubricating properties? Such a test could be a revision of the Axle Rust Test (L-21) to make that test more reproducible, or it could be made a part of either of the two axle load tests. Whatever the test form, it appears wise to stick to the axle. It is an old axiom that "The proof of the pudding is in the eating," and in the final analysis the axle alone is the epicure.

The Story Behind

BASED ON PAPER* BY

R. J. Emmert

Executive in Charge
Facilities and Processes Staff
General Motors Corp.

Last year, SAE Journal carried the story of what cut-wire shot is—and how it performs its work of shot peening and blasting. (See "New Cut-Wire Shot Big Boom to Peening," SAE Journal, August, 1949, pp. 44-51.)

GMC's Process Development Section was called into the shot peening picture to find more efficient ways of using conventional cast-iron shot and ended up developing a new material—cut-wire shot.

Despite its ability to impart long fatigue life, the peening process was found expensive because of the large amounts of shot required. Process Development's initial assignment was to find a way of separating the fine, broken-up shot material from that which was still useful. Aim was to reduce shot usage.

Engineers found that instead of making better use of cast-iron shot, real need was for a material that would not break up readily, and that could be reused many times. Here is how they decided that cut-wire shot was this sought-after material:

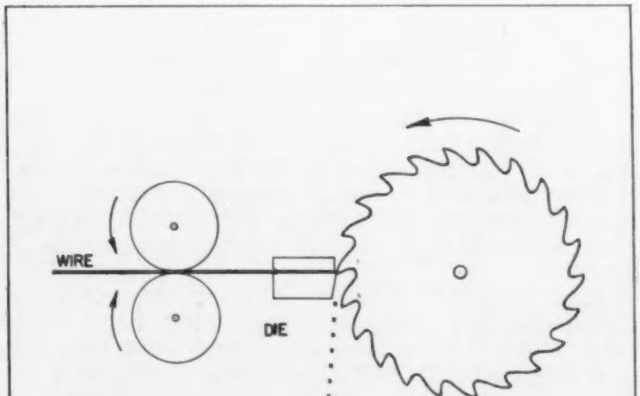
The process involved was peening, not cutting, they reasoned. And since the part to be treated was made of spring steel, specifications for the most desirable shot were fairly apparent. It had to be very tough, yet very ductile, and about as hard as spring steel. All this pointed to cold-drawn spring steel wire with about 65 points carbon and a Rockwell C 50 hardness. SAE 1065 hard-drawn spring wire, a readily available material, finally was chosen.

The following pictures tell the story of how the shot was produced from wire and how cut-wire shot was proved to be better than cast-iron material.

* Paper "Process Development—the Link Between Engineering and Manufacturing," was presented at SAE Annual Meeting, Detroit, Jan. 10, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Cutting Wire into Shot

Shot is made by feeding ten strands of wire into this husky milling machine



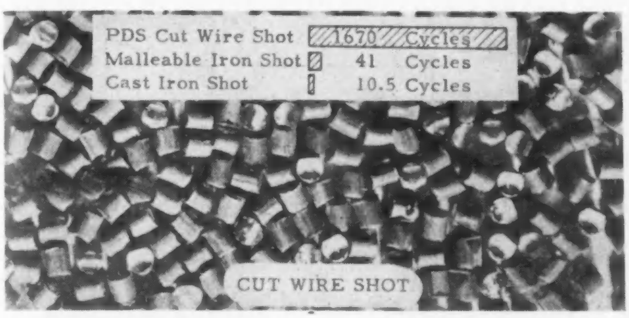
The wire is pulled off reels and fed across a die into a rapidly revolving milling cutter which shears off diameter lengths of wire

Cut-Wire Shot

This article describes:

- **How cut-wire shot was born**
- **Why it was born**

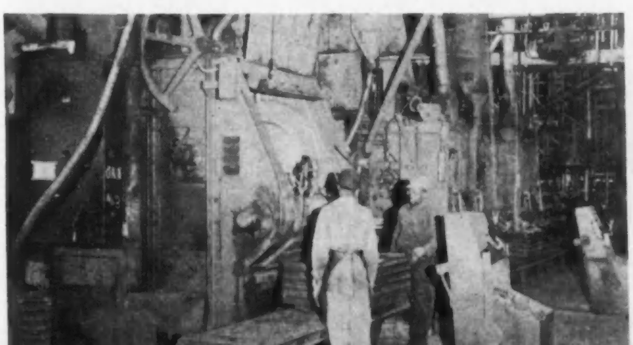
Lasts Longer in Tests . . . . and in Use Too



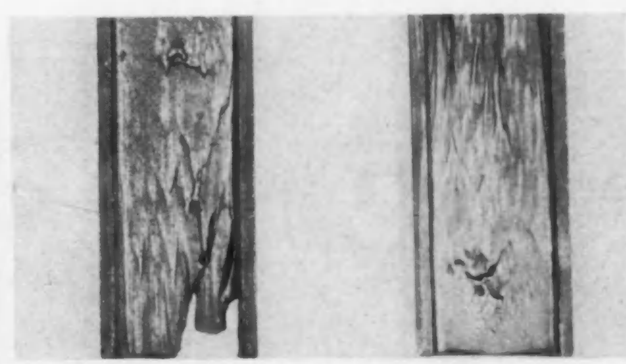
Cut-wire shot ran through many more cycles than commercial shot in a Pangborn testing machine, as the results above show

Compare the condition of chilled-iron shot after 10 passes through a blasting machine (left) with cut-wire shot after 300 passes through the same machine (right)

Cuts Consumption . . . . and Machine Wear



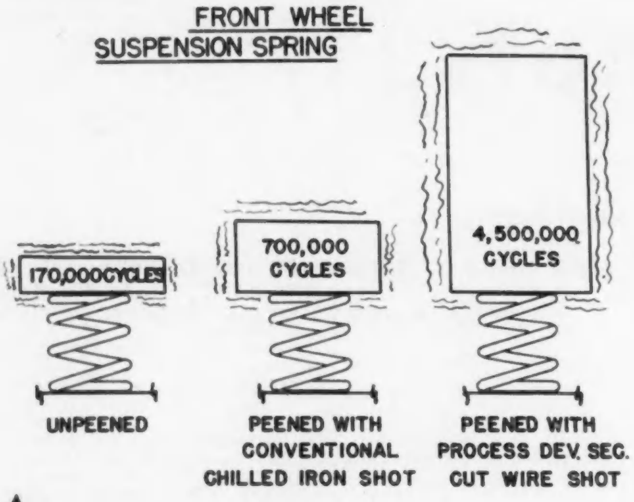
Used in a shot blasting machine above for cleaning castings in the Cadillac foundry, cut-wire shot reduced shot consumption 49% and cleaning cost per part 16%



Average life of impeller blades using cast-iron chilled is 10 days (blade at left). One plant using cut-wire shot required no replacement after 120 days (blade at right). A set of blades costs about $17.60

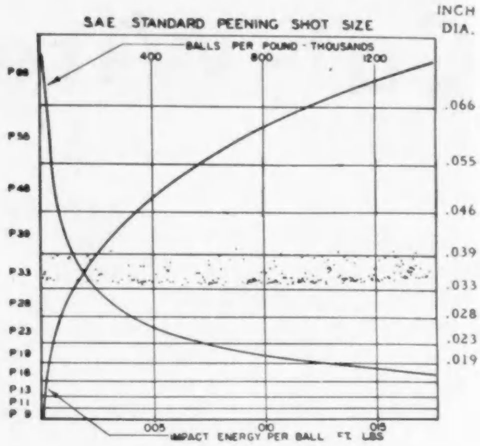
→

Extends Fatigue Life

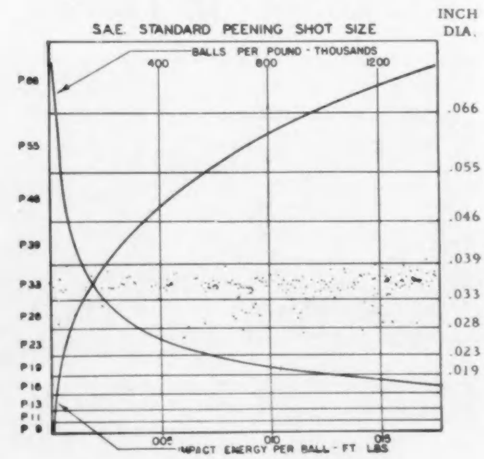


Steel shot has increased fatigue life of front-wheel suspension springs to some 4,500,000 cycles. In fact, they wear out the machines . . . they just don't break

Maintains Size Uniformity



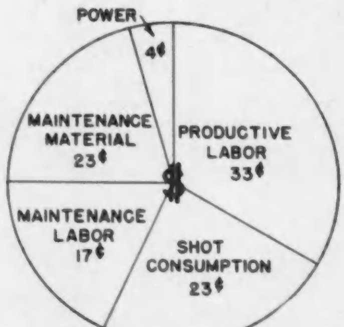
20 Gage New Cut Wire Shot



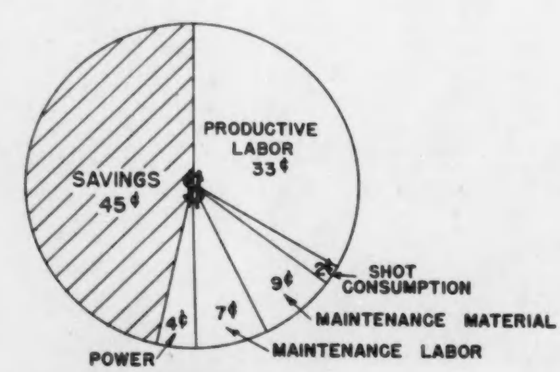
Production Sample After 9 Months' Operation With 20 Ga. Cut Wire.

These are actual photos of new cut-wire shot (upper chart) and used shot after nine months of operation (lower chart). Shot is in a shot classifier, made of two ground glass plates and separated by a tapered air space. Shot comes to rest, depending on its diameter

. . . . . . And Saves Money Too



PRESENT
SHOT CLEANING COST



NEW SHOT CLEANING COST
(45% REDUCTION)

Cut-wire shot saves 45¢ of the cost dollar for average shot cleaning operations. At its present annual consumption of over 8000 tons malleable and chilled-iron shot, General Motors Corp. would reduce its costs from $990,000 to $450,000 (over a one-half million dollar saving yearly) by switching to cut-wire shot

NEW Turboprop Control Uses Fuel-Flow Governor

BASED ON PAPER* BY

George P. Knapp

Project Engineer

Servomechanisms, Inc.*

THE powerplant control system for a turboprop should demand only a minimum of pilot attention, yet give him the power he needs for any ground or flight condition without ever endangering the powerplant. Curtiss-Wright has designed a system that fulfils these requirements by tying fuel flow to rpm and propeller pitch to temperature, torque, or thrust —whichever is critical.

The pilot's needs for a simple power control can be boiled down to a coordinated control quadrant like the one shown in Fig. 1, which satisflies current military requirements. It has three levers, a "condition" level in the center, a "fuel" lever at the right, and a "power" level at the left.

The condition lever has five positions: (1) cutoff, (2) start, (3) ground idle, (4) operation idle, and (5) combat and land. The schedule of power and rpm is different for each position. Table 1 shows the schedule.

The fuel lever is used for manual fuel control during the start condition.

The power lever is operative only when the condition lever is set for operation idle or combat and land. Then it varies power by scheduling the setting of two of the controlling parameters: rpm, temperature, torque, thrust, blade angle, and fuel flow.

The zero setting of the power lever corresponds approximately to zero net thrust. Moving the lever ahead of the zero setting increases power available for forward thrust. Reverse thrust is available below the zero setting in the combat and land condition.

During operation idle, rpm is held within a relatively narrow range near maximum rpm, while

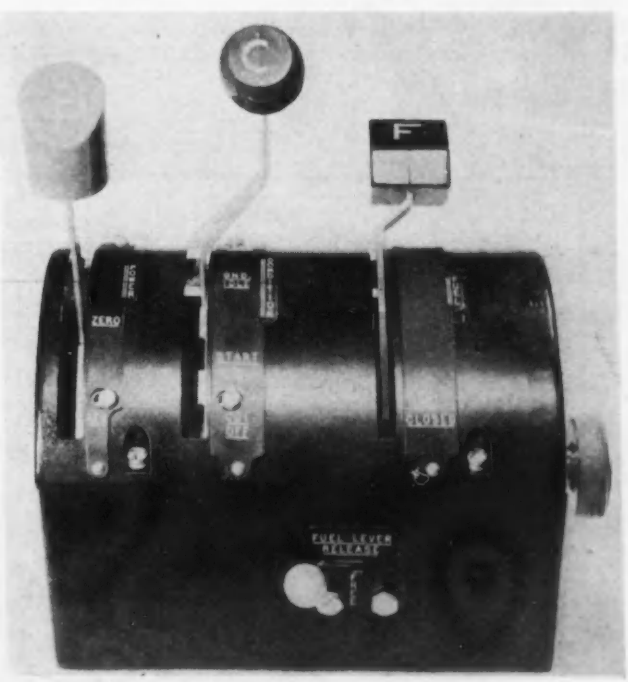


Fig. 1—Coordinated power control quadrant

* Paper "Designing Turboprop Controls" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.) At the time this paper was presented, Knapp was project engineer, Propeller Division, Curtiss-Wright Corp.

Table 1—Typical Requirements at Each Setting Of Pilot's Condition Lever

Condition	RPM, % of maximum	Power, % of maximum
Stop	0	0
Start	0- 60	0-minimum[1]
Ground Idle	60- 80	minimum[1]
Operation Idle	80-100	minimum[1]-100
Combat and Land	100	minimum[1]-100 and reverse

[1] Minimum power is power at which net thrust is approximately zero.

power can be varied over its full range. The schedule is usually arranged to provide essentially minimum fuel consumption for each power setting.

Combat and Land

In the combat and land condition, power is variable over its full range but rpm is held constant at its maximum setting to permit rapid power recovery. This is the only condition in which reverse thrust is available.

(Some thought is being given to omitting the combat and land condition for turbines that can accelerate rapidly. If the idea is carried out, reverse thrust will be provided in the operation idle condition or its equivalent, of course.)

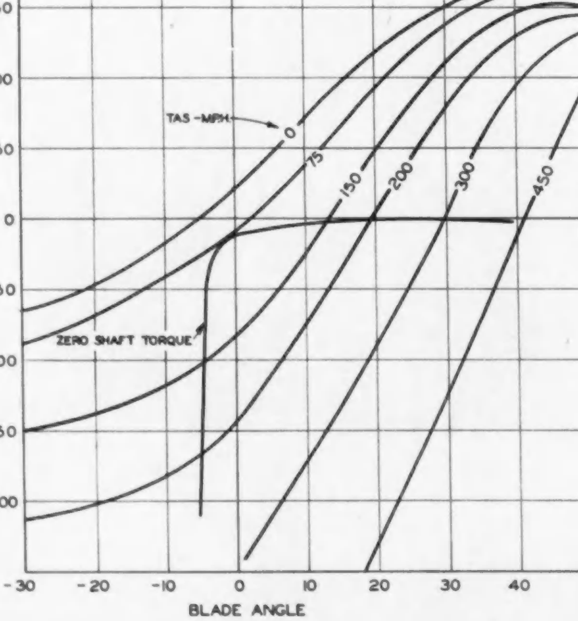


Fig. 2—Typical propeller thrust curves at constant rpm

Net turbine power output increases with rpm and temperature. Maximum power comes from setting and maintaining both these quantities at the maximum values permitted by the strength of rotating parts at high temperatures.

But at some flight conditions, such as high-speed low-altitude flight on a cold day, the maximum rpm-maximum temperature setting can result in a torque too great for the engine's gearbox. That means that, with rpm held at or near maximum for the sake of rapid power recovery or economy, power must be reduced by reducing temperature below its maximum. Therefore, torque, instead of temperature, must sometimes be limited by the control, in order to protect the engine.

Obtaining Zero Thrust

At speeds over 100 mph, torque control can also serve to operate the engine so that the propeller delivers zero thrust. Fig. 2 shows why it can be done: The zero shaft torque curve follows the zero thrust line above 100 mph. Fig. 2 also shows why another control method is needed below 100 mph: The torque curve reverses, and it becomes impossible at lower speeds to obtain zero torque.

Fortunately zero thrust can be obtained at speeds lower than 100 mph by a control which sets the propeller to a blade angle predetermined to be the one producing zero thrust. (Theoretically this method could be used at higher speeds too, but expected inaccuracies of the blade angle computer would make it impractical at the higher air speeds, where blade angle may vary only 3 or 4 deg between zero thrust and maximum power.) Decreasing the blade angle below the zero thrust position by moving the power lever into the reverse thrust region supplies braking action at landing airspeeds.

Of course, these two thrust control methods are used only because direct thrust-measuring devices are not presently available.

System Described

All these functions of the control system must be obtained through only two controllable variables: fuel flow and propeller pitch.

Turbine rpm can be controlled through a propeller blade angle governor, as is done with reciprocating engines, or through a fuel-flow governor. Curtiss-Wright engineers decided on the fuel-flow governor for these four reasons:

1. Rpm and thrust must be controlled simultaneously at low airspeeds, and adjustment of propeller blade angle is being used to control thrust.

2. Near the zero-thrust blade angle, and at low airspeeds a propeller governor would be incapable of controlling rpm (although it could be used at greater angles).

3. If the propeller is controlling torque or temperature and the fuel supply fails, the propeller control tends to increase propeller blade angle. This amounts to automatic propeller feathering. (If the propeller is controlling rpm and the fuel supply fails, the propeller decreases blade angle in its effort to maintain rpm constant. This can lead to severe propeller drag, a situation which could be disastrous during take-off.)

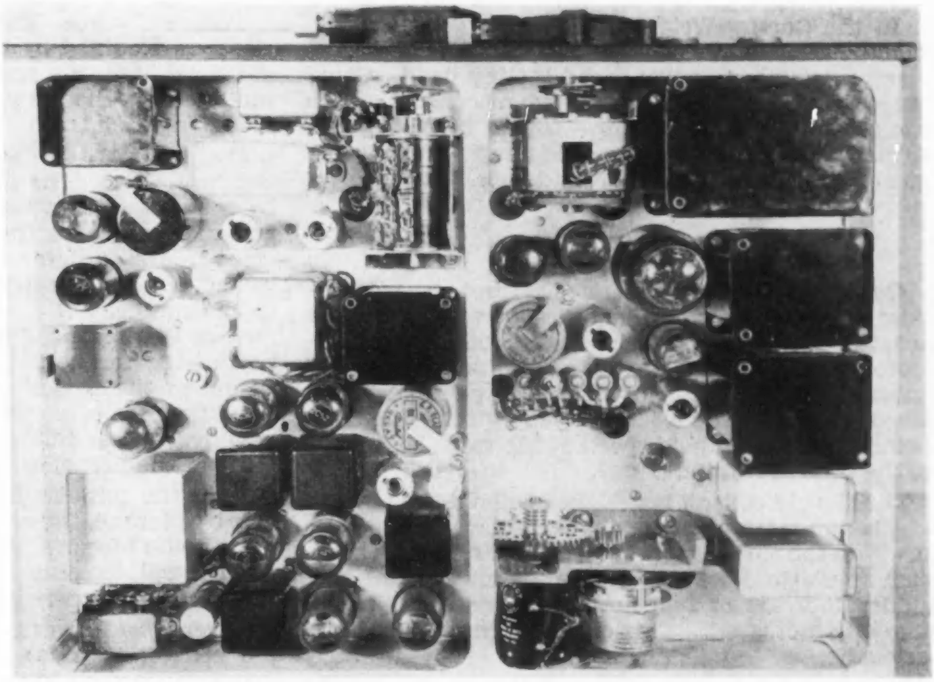


Fig. 3—Interior of electronic turbine control computer

4. When a pilot calls for a higher rpm in the operation idle condition, it is because he needs more thrust. The blade angle power control gives it to him by increasing blade angle, while increased fuel supplied by the governor brings up the rpm. (In a propeller-governed system, the call for an increase in rpm would tend to decrease blade angle, giving less thrust at first instead of more. Overcoming this difficulty requires a device which delays the increase in rpm called for slightly, so that the rpm of the powerplant during the transient is always a little greater than the governor speed setting.)

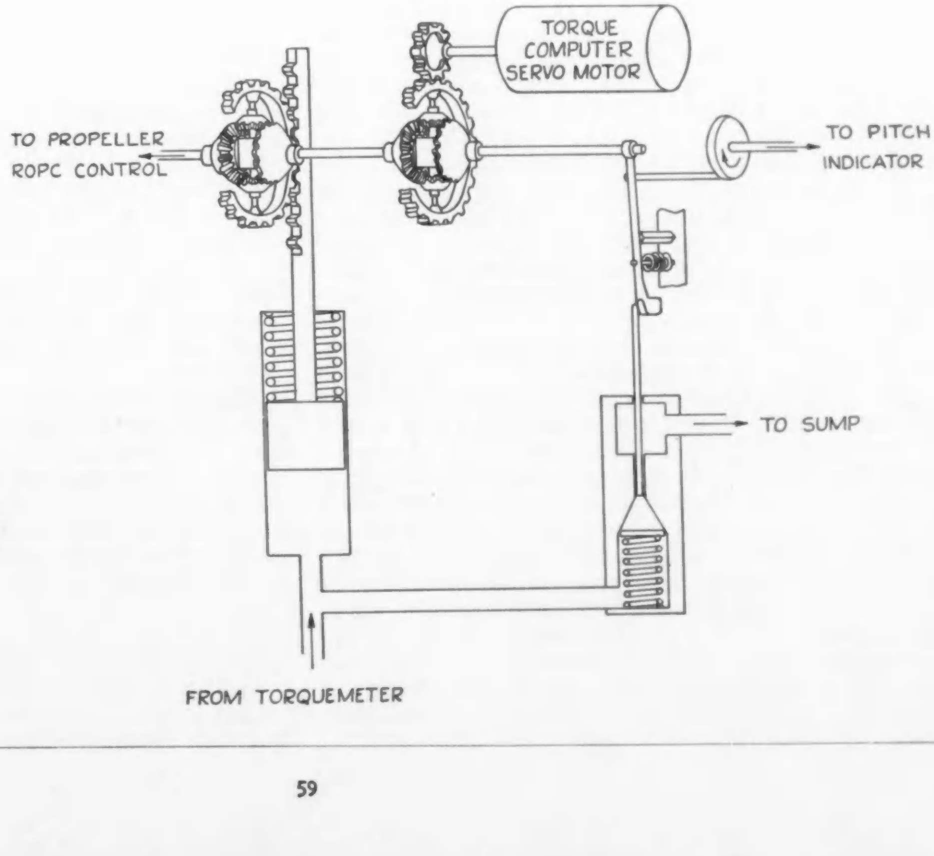


Fig. 4—Schematic diagram of torque control. ("ROPC" stands for "rate of pitch change")

In the Curtiss-Wright control, the governor is a modification of the Woodward type, fitted with an electronically controlled speed-setting head. Other major components of the powerplant control system are a computer which figures torque corresponding to maximum permissible turbine temperature, a torque control, and a propeller blade positioning servo.

Regulating RPM

Governor—The governor's electronic speed-setting head avoids the difficulties of setting speeds accurately through a mechanical linkage from a remote cockpit. Doing the job electronically does not reduce basic reliability of the mechanical governor much because if the electrical supply fails, the governor continues to hold speed at the value called for at the time of failure.

The remote control is designed to hold the rate at which rpm setting can be changed down to the rate at which the turbine can accelerate safely. Without such regulation, the governor tends to cause a large sudden increase of fuel flow when speed setting is suddenly increased. This could overheat a turbine seriously.

With rpm being controlled exclusively by fuel flow adjustment, all other control requirements must be met by blade angle adjustment.

Regulating Blade Angle

Computer—The power control avoids the problem of measuring turbine temperature reliably and rapidly by the expedient of controlling torque instead of temperature. At any given combination of flight condition and rpm, torque happens to vary almost linearly with temperature. The torque at which maximum temperature is reached, however, varies over as much as a four to one range with flight conditions. The job of the computer shown in Fig. 3 is to recognize flight conditions from measurements of such quantities as ram pressure, ambient pressure, and ambient temperature, then determine the torque which results in maximum permissible temperature at any flight condition.

Errors in computer calibration are bound to be present. To avoid the possibility of operating continuously at an excessive temperature, the computer is overridden at the maximum-power setting of the power lever by a low-sensitivity temperature control. This operates from four chromel-alumel thermocouples inserted in the turbine tailpipe. (Thermocouples sufficiently durable for this service respond too slowly to be useful as primary temperature controls.) If the computer mistakenly allows overheating, computer output is trimmed slowly until the predetermined maximum temperature is obtained. Slow correction prevents destabilizing the control and masks the changes in torque.

When the pilot advances the power lever, calling for increases in both rpm and torque, an interlock delays the torque demand until the rpm change is completed. Without such an interlock, the torque load on the turbine would increase rapidly and cause overheating, since rpm would not yet have reached the point where the increased torque would be available.

Torque Control—The signal from the torque computer as modified by the pilot's power-lever setting is transmitted to a propeller blade positioning servo mounted on the turbine, which forms part of the blade angle control.

Fig. 4 shows the controller gearing arrangement schematically. The indication of torque called for by the power lever setting is applied by the torque computer servo to the ring gear of a differential. One of the differential's sun gears is normally locked, so that the signal is transmitted unchanged to the sun gear of a second differential. The ring gear of this second differential receives the indication of the torque being obtained. Therefore, the output of the second differential is proportional to the difference between torque called for and torque obtained. This difference signal goes to the control shaft of the propeller.

Since the torquemeter is incapable of registering negative torque, the computer is adjusted to call for a minimum torque slightly above zero. This enables the control to remove any overcorrection which might occur when reducing power.

At very low forward speeds and at standstill, torque control becomes impossible at the minimum power setting, as Fig. 2 showed. Then a manual blade angle control overrides the torque control. Blade angle decreases as the propeller tries to find a blade angle which will fulfil the torque requirements. When the blade angle has decreased to a predetermined value, a mechanical pitch indicator connected to the control is applied to the normally fixed sun gear of the first differential in a direction to prevent further decrease of pitch.

The blade angle setting at which this "beta" control comes into action is a compromise between the zero thrust angle at standstill and the angle at which the torquemeter loses control at low forward speeds.

Reverse Thurst Control—Movement of the power lever beyond the minimum power setting into the reverse range sets the positioning servo proportionately below the minimum torque setting. Blade angle then decreases until it is stopped by the action of the pitch indicator. At this point, the power lever becomes a direct control of blade angle in the reverse range. The torquemeter is bypassed, so that the blade angle setting is unaffected by the increasing torque obtained as the propeller decreases pitch. The reverse blade angle limit is set low enough so that the power rating of the turbine is never exceeded, yet there is ample reverse thrust under any condition.

When the condition lever is set to the start position, the positioning servo is set slightly below the zero torque setting to insure that the propeller will receive a decrease-pitch signal until the proper starting blade angle is reached. Fuel is controlled manually by the quadrant's fuel lever until the turbine reaches ground idle rpm. Then the governor takes over control.

When the condition lever is set to the stop condition, the positioning servo is set to the maximum torque setting and the fuel is cut off. Then the propeller feathers at the maximum permissible rate —that is, the rate which causes torque to approach the limit established for the reduction gearing.

THE YOUNG ENGINEER

—What Industry Expects of Him

EXCERPTS FROM PAPER* BY

A. T. Colwell

Vice-President,
Thompson Products, Inc.

THE most important individual in the world to you is *you*, yourself. Every person who has ambition is an individualist and not a collectivist—he would rather be on his own than take his chances in any mob, asking only the opportunity to "make good." He is an optimist, he has pride, and a desire to acquire knowledge which will bring about his advancement.

Boss Kettering has aptly stated: "The man who can make the best decision at the time it has to be made has the best education and it matters not how he acquired that ability." Stated another way, education is the knowledge of how to use all of oneself. Many men use one or two faculties out of the score with which they are endowed. The man with the best educational background should be able to make the best decision, but this is not always true, as judgment and practical experience may be important factors. For years, in our own plant we fitted tubing into a forging by drilling a hole in the forging and swaging the tubing end solid. One day a shopman asked "why," as the forging was already solid and the tubing hollow. Since that time we have fitted the solid forging into the hollow tubing.

Gen. Donald Putt, director of research for USAF, states: "Above all else learn to get along with people and work with people." Lack of this ability has caused otherwise competent men, technically, to block their own advancement.

Very few jobs are the one-man type—practically all are done as a team where there is contact with others of the group. It is necessary, therefore, to "get on the team" . . . to work cordially with other people. As SAE President James C. Zeder, chairman of the Chrysler Engineering Board, clearly states: "In any organization, people must fit themselves to jobs rather than creating jobs to fit people." I cite the case of a brilliant engineer and mathematician who never learned this principle. One day a foreman burst into the chief engineer's office shouting, "If that man ever comes into my department again, I'll bust his head." The engineer's value was gone excepting for a job on which he could work alone, as he had the faculty of stirring opposition and antagonism wherever he contacted other people. Avoid developing into the type of engineer who is too opinionated, knows all the answers, who is "misunderstood," and thus stifles any cooperation which is offered.

Stanwood W. Sparrow, vice-president of engineering of Studebaker and an SAE past-president, offers this suggestion: "Enthusiasm for a job often counts as much as knowledge—the job gets done." No man in any walk of life ever was outstanding who did not have enthusiasm for his work—not for six months, or six years, but all through life. Very often, particularly in research or development work, a director will choose a man of good technical background who knows little about a given project, but who has enthusiasm and wants to try. Frequently best progress is made by a man who doesn't know all the ways a thing cannot be done. The man who is fired with enthusiasm for his work is seldom fired by the boss.

James L. Myers, president of Cleveland Graphite Bronze, says: "Engineers have a strong sense of in-

* Paper "What Industry Expects of the Young Engineer" was presented at an SAE Student meeting, Los Angeles, Oct. 10, 1949.

tegrity. Early in their education they are taught to think honestly and this is a highly important characteristic. Don't ever lose it." Intellectual honesty reports facts as facts and theory as theory. The reputation for accurate statements can be a valuable asset. There is no discredit in saying, "I don't know," provided that you immediately proceed to find out.

Walter Strehlow, chief engineer, Tractor Division, Allis-Chalmers Mfg. Co., makes this observation: "Guard against discouragement in your early years." At such times, a bit of sound philosophy will help, applied to long-range perspective. You should realize that the moment you put a line on paper for a new design, you are subject to criticism from some source.

Some jobs may seem trivial, but in every case ability will stand out. Surprisingly, some of the smaller problems are more difficult to solve than the larger ones. No job should be considered beneath your capacity—do each one well, with prompt follow-through. Kettering once gave a young metallurgist the job of heat-treating a piston, which appeared too simple for a man of his technical background. He treated the piston in a short time, but was three years learning how to correct the warpage which resulted. Mistakes may be made, and are to be expected—but the same mistake should not be made twice, and the mistakes must not outnumber the correct answers.

The young engineer should expect to study harder than he ever did at school, to keep abreast of ever-changing developments. Join the society of your chosen field, whatever it may be. The society journals publish current information not found in any textbook, and by attending meetings you may rub elbows with more experienced men and gain much by associating with them. In the engineering fraternity you may be surprised to find how willing the older men are to help along the younger man who has enthusiasm for his work, and wants to learn.

The ability to express yourself clearly and easily is very useful. The boss wants your ideas, particularly if they are explicit and understandable, but he wants clear, direct answers to his questions. In this connection, the study of engineering induces analytical thinking. In experimental or research work, usually a mass of data and facts is assembled. The director of the project wants this mass of data screened, the important items correlated in a concise manner indicating the result, and recommended action based on that result. The short, clear summation is far more difficult than the long rambling type, and is more valuable. Such tasks develop the faculty of judgment so important to an engineer, and the faculty of understanding.

E. H. Kelly, chief engineer of Chevrolet, says that he wants his men to be "on the team," to show initiative, but *not* to take over the other fellow's job. He likes an engineer who is not afraid to get his hands dirty, and who will submit his own ideas to the boss. Misunderstandings are going to occur in any group, no matter what is done to prevent them. He suggests that a frank discussion among the parties involved clears the atmosphere quicker than anything else, and misunderstandings should be cleared promptly.

In conclusion, may I suggest the following thoughts: The opportunities in engineering are greater today than ever before, both directly in the field of engineering and on up through management. Your greatest problem is to be prepared for opportunity when it comes. There is no terminal point to progress in a free America.

SAE National Passenger Car, Body and Production Meeting

Continued from page 17

think we must make an even greater effort to reduce production costs, to improve quality, and to increase the value of our products. Those aren't new goals, but they are even more important today and are becoming more difficult because of increased wages, pensions, and higher material and transportation costs. Added to these are taxes, both the hidden kind and those applied directly, which continue to pyramid.

The progress we in the industry have already made in reducing production costs has narrowed the possibilities considerably. The chances for larger savings in individual operations on manufacturing items are fewer. This fact points up the need within every company for better coordination between manufacturing, in all its phases, and product design and engineering."

At Technical Sessions

In all phases of car design and manufacture, automotive men thought out their problems in terms of "what have we got, what do we want, and what's standing in the way of this goal." To serve up a better product, engine men, suspension specialists, materials handling engineers, glass technicians, and brake designers focused on greater economy, comfort, and safety in passenger cars.

Same Engine Design Criteria Still Hold for Fuel Economy

Engine men checked their design concepts in the light of nuclear energy and reassured themselves that continued improvement along non-atomic lines still offers a promising plum. Despite collapse of the age-old theory that energy and matter are indestructible, the piston engine continues to behave in the same way.

They pointed out that the stuff burned in an internal combustion engine is a gas with a fairly definite energy content. The problem, they agreed, is how to convert that energy into more useful work or (miles per gallon for the motorist) than is the case with present engines. A-bomb and H-bomb developments notwithstanding, higher thermal and volumetric efficiencies are still the way to higher fuel economy, they noted.

Although the economies they produce are only indirectly passed on to the car owner, body engineers showed how their designs ease materials handling to cut transportation costs. Parts must be designed to keep weight-to-bulk ratio at a minimum. Steel stampings and assemblies shipped to assembly plants are of hard-to-handle sizes and shapes. Objective in their design is to keep from paying for shipment of air represented by the unused space between parts packed in a railway car or truck.

PASSENGER CAR

E. N. Cole

BODY

R. A. Terry

PRODUCTION

R. F. Steeneck

MATERIALS

R. W. Roush

The four activities participating in the meeting are led for 1950 by Vice-Presidents E. N. Cole (Passenger Car); R. A. Terry (Body); R. F. Steeneck (Production); and R. W. Roush (Materials)

All engineers at the meeting had thrown at them a challenge to effect motoring economy more directly—building a four-passenger, shorter wheelbase car. More than ever before, motoring facts of life in this country are in closer agreement with the plus values of such a small car, argued a producer from abroad.

First, he reasoned, "many of the false, imaginary requirements in luxurious motor car transportation are losing validity and appeal." Second, a four-passenger car, such as the Austin, can carry the average American family (3.67 persons). In fact, four six-footers can ride in an Austin with comfort. In this case a smaller car doesn't mean less room, it was reasoned, but room without waste.

Durability, fuel economy, and driving convenience also were spotted as small car features. Four-cylinder engines have held up under rigorous racing and driving conditions. Average fuel consumption of 30 mpg with cars like the Austin cuts gasoline costs from 2¢ per mile (for many American cars) to nearly 1¢. And the shorter wheelbase was considered particularly attractive in congested city traffic, on narrow streets, and for parking in tight spots.

American engineers noted that resale value plays

SAE President Zeder

said: Speaking at the dinner that closed the SAE National Passenger Car, Body, and Production Meeting, SAE President James C. Zeder told engineers they must help maintain progress in the automotive industry by preventing imposition of restrictions fostered by outside organizations. He said, in part:

"All these groups are motivated by an entirely legitimate interest in certain problems of our everyday existence that are related to the automobile.

"Unless the automotive industry is responsive and alert to the problems with which these organizations are concerned, this influence might be brought into use in such a way as to impose unnecessarily restrictive conditions which would hamper further development.

"In some cases the industry has been charged with responsibility for failings over which it has no control. Only the automobile engineer is in a position to refute these arguments when they are without basis in fact.

"The automotive engineer's chief line of defense is an adequate knowledge of the tremendous range of problems which attend the use of the automobile. He must stop thinking of the automobile merely as a collection of technical problems, and be able to see it from the social, economic, and cultural standpoints.

"This is not an easy thing to do. As automotive engineers we are accustomed to looking at the automobile against a background of technical education and experience. If we are to see it also from these other standpoints, it means that we must develop a new frame of references, and this requires a great deal of broadening on the part of the average engineer.

"Instead of shutting ourselves off from all but technical pursuits, we must take an interest in and assume a responsibility for, such problems as government, politics, taxation, the American enterprise system, education, social reform, and even foreign relations. No responsible person has the right to ignore these things, and the engineers who played such a large part in creating the complexities of modern civilization have a particular obligation to society in this regard."

a big part in the new car buyer's deliberation over which car to buy, and doubted whether trade-in values of a small car would hold up. An Austin dealer at the meeting advised that it's practically impossible to find a second-hand Austin today, in areas where the company has good sales representation. And resale values range from $900 to $1050, depending on the area, which is a fairly good indication that the second-hand price is holding up.

Skepticism over the cut of the car market which would buy such a car was met with a report of a survey that revealed every class of car buyer is represented by Austin customers . . . two-car families, used-car owners, people who haven't ever had a car, and those who can't afford to operate an American car.

The claim was made—partly facetiously and partly seriously—that the prestige-conscious American car owner, who feels he's judged socially by the "heap outside his door," also can have a light car serve his particular purpose. Said an Austin man: "If you buy a Ford, Dodge, or Cadillac, neighbor Brown may feel he has a basis for estimating your income. But drive a small car like the Austin and he just can't tell."

Emphasis of the meeting swung from cost considerations to riding comfort. Suspensions designers said that current suspensions—both front and rear—are basically well-suited to their jobs. Relatively low in cost, they offer almost all that is wanted in spring flexibility in vertical, horizontal, and roll directions. Current ride-improving measures, they said, are aimed at eliminating secondary vibrations (wheel disturbances imposed by road surface uneveness). This wheel hop is passed to the frame and body as a shake or harshness.

Analysis of suspension geometry and dynamics proved wheel hop to be a function of tire flexibility. Front suspensions give engineers an added headache, since the stabilizer bar, necessary for good steering and handling, tends to aggravate side shake and harshness.

Glass and Brakes Head Safety Considerations

Safety aspects of the meeting concentrated on window glass and brakes. Review of automotive glass progress showed how new plastic interlayer materials, such as polyvinol, made possible bent safety glass to curves and dimensions thought impossible 10 years ago. Heat-absorbing glass, which permits clear, obstructed vision without the discomfort of open-air exposure to sun heat and glare was cited as another advance.

Despite these and other developments, glass technicians noted that they cannot defy optical laws which govern both light and vision. Bent glass cannot be used without changing the path of light passing through it. Inclining even a flat piece of glass disturbs vision. Internal reflections become noticeable by bending the sheet, which further distorts vision.

Production Clinic Leaders...

Nearly 500 engineers participated in the all-day Production Clinic, led by these panel heads. They are (left to right): N. E. Rothenthaler, Ford Motor Co., Body Steel; A. F. Underwood, General Motors Corp., Surface Finish; E. H. Stilwill, Dodge Division, Chrysler Corp., Steel Heat-Treating; R. P. Lewis, Spicer Mfg. Division, Dana Corp., Gear Design and Production; Joseph Geschelin, Chilton Co., Clinic chairman; H. E. Hardenbrook, Buick Motor Division, GMC, Preventive Maintenance of Plant Equipment; J. N. Berrettoni, Dr. J. N. Berrettoni and Associates, Inspection and Quality Control; and O. E. Johnson, Kaiser-Frazer Corp., Materials Handling. Leader of the Production and Manufacturing Control Panel was G. S. Wilcox, Plymouth Division, Chrysler Corp.

Body stylists were told that the newer trend to sharply-tilted and curved windshields, coupled with high-intensity sealed beam headlamps, has brought double vision into sharp focus. Preventing further aggravation of this condition was urged.

Fact is, said a glass engineer, any piece of even flat plate glass has double vision in it. But if the windshield were vertical and normal to the line of travel, double vision would be hardly noticeable. Sloping and bending the glass simply moves the secondary image further away from the primary, and that's what impairs vision.

He recommended that car engineers keep glass bend radii above 20 in. Below that, distortion and double vision make it tougher to see through the glass.

Brake design discussions left engineers at the meeting divided into three camps: (1) those favoring disc brakes, (2) those still unwilling to switch from drum brakes, and (3) the "let's wait and see" group.

Disc brake adherents felt current brake drum designs have reached their maximum ability to dissipate heat. Recent driving trends are putting an added load on brakes faster than improvements in brakes can handle the load. Average and top car speeds as well as car weight are going up, putting and ever-increasing heat burden on brakes.

Available coasting ratios in new automatic transmissions don't give the braking effect of conventional three-speed transmissions. Tires have become larger, wheels smaller. The trend toward moving a larger proportion of the car weight forward requires the front brakes to handle up to 62% of the total braking. And the demand for easier driving includes reduced brake pedal effort. All these new conditions, some argued, justify a switch from band to disc brakes.

Drum brake proponents agreed as to the growing demands being placed on brakes, but disputed the call for abandoning the drum brake for the disc type. Shoe brakes have inherent reliability, effectiveness, efficiency, simplicity, and low cost too. Remove the low cost limitation, these brake men ar-

Production Clinic Reports

The May issue of the SAE Journal will feature blow-by-blow reports of the information and experiences exchanged at the eight Production Clinic panels. The panels to be reported are:

- Materials Handling
- Production and Manufacturing Control
- Gear Design and Production
- Preventive Maintenance of Plant Equipment
- Inspection and Quality Control
- Surface Finish
- Steel Heat-Treating
- Body Steel

gued, and you can build in forced ventilation and other features which will permit the conventional brake to stand up under tougher service conditions.

Discussions moved from jobs to be done for motorist and pedestrian to efforts to prevent industrial wastes from becoming a health hazard and nuisance to the plant community. Engineers and chemists urged industry self-regulation of waste disposal rather than risk restrictive ordinances by angry municipalities.

They warned that strong acid wastes destroy sewer structures, have adverse effects on biological methods of sewage treatment. Too strong an acid concentration in natural streams also may destroy fish life if the pH drops much below 4.5.

Smoke also can do costly damage, an air pollution expert advised. He said St. Louis suffered a 19-million dollar loss in 1937 from smoke damage, and Chicago 30 million dollars. All told, air pollution has been estimated to be costing this country one and one-half billion dollars per year. Average per capita expenditure for atmospheric pollution control in American cities is 7¢.

The Donora disaster swelled the crescendo of public demand for air pollution abatement. Restrictive laws against such industrial negligence in waste disposal already are on the books of cities, states, and the federal government. It won't take much more neglect by industry to put teeth into enforcement of such regulations.

Particular emphasis was given to the smoke pollution difficulties in Los Angeles. This problem has grown serious because of (1) a 500% growth of industry since 1939, and (2) a hot layer of heavy air, brought in from the ocean, which holds in pollution and prevents its dispersal. It was estimated that on one bad smoggy day, some $250,000 of truck farm produce was ruined.

One school of thought had it that motor vehicle exhaust smoke was a big contributor to the city's air pollution. However, the level of concentration from this source was found to be too low to give any trouble.

Second reason given for controlling industrial wastes is to recoup some of the still-usable chemicals in them, particularly in plating wastes. In one plant with acid wastes of 25,000 gal per day, 34,800 lb of chromium trioxide, worth about $9600, could be recovered every year.

Definitions of problems and goals in the economy, safety, and waste-disposal areas set up a foundation for evaluating ways and means to desired ends. Some solutions had already been achieved, others merely indicated, but neither lacked for vigorous debate.

Find Potential Gains In Mechanical Octane

Researchers aiming for ways of designing engines and fuels to retrieve more useful work from gasoline told of clues to such gains. Tests with four type of combustion chambers with compression ratios of from 5.7 to 15 to 1, and other investigations of knocking characteristics at compression ratios of 21.3 and 30 to 1, produced much provocative information.

One significant discovery is that turbulence produces engine mildness toward sensitive fuels. Although not large at 7.3 compression ratio, severity reduction due to turbulence becomes important at 10 and 15 to 1 compression ratio with high rpm.

This work has unveiled turbulence as a rich source of mechanical octane numbers, research men reported. Difference between poorest and best combustion chamber design, from the standpoint of turbulence, they found, may mean as much as seven fuel octane numbers gained in the 93-100 octane range. Therefore, a well-designed engine can give 100 octane performance with 93 octane gasoline.

Use of squish pistons and shrouded valves in this work was viewed as helpful for academic evaluations, but impractical in commercial engines because of mechanical limitations, especially at higher compression ratios. However, engine men welcomed suggestion of greater turbulence because of its help in reducing combustion chamber deposits, Deposits in service, they said, cut power output and boost the engine's octane requirement.

Engineers at the meeting lined up in two opposing camps as regards effects of hot exhaust valves on knock. Some said it mattered, most said it didn't.

Two independent researches failed to find any material gain in mechanical octanes by cooling the exhaust valve. One group made the comparison between sodium-cooled and solid valves. In the other study, the valves were water-cooled and then run without water. Despite the wide temperature difference between these two conditions, no effect on octane requirement was noted.

The dissidents argued that hot spots, such as exhaust valves, are deterrents to building mechanical

octanes into the engine. In fact, it was suggested that engines without exhaust valves (sleeve-valve engines) should yield a big knock reduction.

From research-indicated economies, engineers at the meeting turned to transportation cost savings already being achieved by body-parts design. The seemingly unrelated factor of materials handling in transit is reflected in parts design to eliminate payment for shipping "air." Key to such cost saving, materials handling men said, is arrangement of components and sub-assemblies to nest with a minimum of air space between them. This is done wherever possible without interfering with design or increasing assembly difficulties.

Nesting considerations were said to be a two-part job. First, design of sheet steel components making up the body shell are determined early in the program. Second, decisions are made relative to installation of braces, brackets, and reinforcements. The problem boils down to this: Shall the particular structural member be installed at the fabricating plant or at the assembly plant? How do the costs compare? Which is the more efficient?

Bright Cost Picture Seen for Light Car

The "how" of motoring economy from a more basic standpoint—the small car—centered on design specifications which would make for acceptability by the American market. By way of example, a British light car maker pointed to the Austin as a suitable combination of design factors. It has a 92½-in. wheelbase, 152-in. overall length, weighs 2250 lb, is powered by a 4-cyl engine with 7.2 to 1 compression ratio, and can accelerate from standstill to 50 mph in 20.5 sec.

The 100-in. wheelbase Ford Model T, he continued, met with good reception in this country because of its fuel economy and engine simplicity. He reasoned a car with similar specifications would find a big American market today.

American car engineers pointed out that building a car with Model T specifications would make for a less rosy cost picture than apparent at first glance. Here's why:

Rough estimates show that a 30% reduction in car weight and size permits only a 10% cost reduction. On the basis the current American low-priced car still presumably would look like the more attractive buy.

The British motor man felt that the 10% cost reduction probably was predicated on a low-volume production. He argued that it stems from the American producer's underestimate of the light car's market potential. Fact is, he continued, Austin can't produce fast enough to meet American commitments. The more the American public would see and find available such light cars, the greater would be its acceptability of such a vehicle.

More comfortable riding was claimed for American cars as compared with light-weight European types. Suspension engineers told how they are striving for still better ride characteristics to eliminate wheel hop, body shake, and harshness.

Road test data has shown viscous type shock absorbers to improve overall ride and control at higher speeds. With viscous control, shake and wheel hop are effectively attenuated above 40 mph. Up to 40 mph, horizontal and vertical shake and wheel hop tend to increase very slightly.

Another ride-comfort fact disclosed at the meeting is that vertical shake and wheel hop increase with tire pressure at all speeds. Body side shake is a minimum at 24-psi standard tire pressure at speeds of 30 to 50 mph. Tests also show that the roll bar tends to increase side shake without greatly affecting vertical shake. That's because the roll bar permits greater freedom in the vertical direction.

Philip H. Pretz

Joseph Geschelin

Arrangements for the meeting, attended by over 1000 SAE members and guests, were made under the aegis of General Chairman Philip H. Pretz (above), Ford Motor Co. General Chairman of the Production Clinic panels was Joseph Geschelin, Chilton Co. (below)

Car engineers heard that radius arm length ties in with brake and power hop. For minimum brake and reverse power hop, a long effective radius arm was recommended. A short arm was said to be best for minimum forward power and reverse brake hop.

Designing safety into cars carried over to the glass and brake areas. Among the newer glass developments described were tempered glass and electrically-conductive glass.

Tempered safety glass, a single piece of glass, was claimed to have many attributes. It is made by being heated to a high temperature and then suddenly quenched in a blast of cold air. This process places outer glass surfaces under compression and the inner glass body under tension, making the glass up to five times stronger than annealed glass.

When fractured, tempered glass disintegrates into tiny fragments resembling rock candy. None of the fragments weigh more than 0.15 oz, so that a car occupant will not be seriously injured, unless a fragment should strike the eye. Another advantage reported for tempered glass is that in breaking, it tends to hold itself in place. If not restrained by

some framing, fragments tend to scatter in the plane of the glass, rather than at right angles to it.

Better visibility under icy conditions were forecast with a new product called Nesa, which conducts electricity. It can dissipate enough energy to keep a windshield—even a high-speed airplane windshield—free of exterior icing or interior fogging. Although factors such as high amperage, relatively high voltage, and temperature control have delayed its advent in car windshields, glass men predicted these obstacles will be overcome in the not-too-distant future.

The disc-versus-shoe brake discussions focused on design and construction as a means of explaining the plus values of each.

Disc brake designers gave biggest emphasis to the self-energization feature of the brake. It's done with six steel balls, which are forced to climb ramps in the pressure plate ball pockets as the plates are rotated relatively by the wheel cylinders. Self-energization can be varied up or down, to accommodate any friction coefficient or service requirements, by changing the ramp angle.

While high self-energization was said to be desirable for low pedal effort, too much of it may make the brake over-sensitive and induce self-locking. The disc brake described at the meeting also features a simple self-adjuster to compensate for lining wear. Unlike a drum brake, the disc brake does not have to compensate for thermal or mechanical deflections. A constant clearance is maintained between the linings and friction surfaces of the housing.

Shoe brake advocates argued that there are a variety of drum brake designs available to meet specific service needs. For example, varying degrees of brake effectiveness (ratio of brake output to input) are available. The Duo Servo type, which is equally effective in both directions of drum operation, is said to do the most work. The Twinplex for front axle installations, more effective in forward drum rotation than in reverse, is next. The Non Servo is least effective. They were rated on theoretical effectiveness in the ratio of 5 for the Duo Servo, 4 for the Twinplex, and 3 for the Non Servo.

One engineer summed up the brake situation by noting that the new disc type is not to be denied. It's still in its infant stages, and "learning to walk"; but it is in production and in use. Only in this way can brake men learn of the disc's bugs and engineer them out of the design. As in any other product's development, the disc brake will be gradually improved, so that 10 years from now it may not even resemble its forefather of today.

The how-to phase of meeting discussions shifted to methods of controlling industrial wastes. Several approaches were suggested—preventing the condition, rendering the waste products harmless, and recovery of usable parts of the waste for reuse.

A specialist in air pollution urged smoke prevention by designing the equipment to suit the fuel used. He said any fuel can be burned smokelessly, but good equipment design, intelligent management, and skilled operation are musts.

Acids can be effectively disposed of, another engineer said, if they are diluted by mechanical mixing or distributed into the receiving water. Usually the traversing of a municipal sewer system for some distance does the mixing. But disposal directly into a lake or stream calls for elaborate dispersal methods to avoid localized lethal concentrations.

In one case acid waste disposal into a municipal sewage system actually proved beneficial. Iron pickling liquors admitted to the Kenosha, Wisconsin system improved solids removal by acting as a coagulant. But when the wastes cannot be diluted, they should be neutralized. Adding familiar alkaline agents—such as lime, dolomites, soda ash, and ammonia—turns the trick.

Soluble oil wastes were said to present a ticklish problem because treatment method varies with the character and composition of the oil. However, emulsions can be readily broken down by adding an acid or salt. And water containing small quantities of oil can be clarified by coagulation. A combination of both processes was found necessary by one plant to get the low oil content required by stream control authorities.

This company built a disposal plant through which all wastes from various operations and buildings are channelled. Here chemicals are added, the oil permitted to coagulate, and settle out. The sludge is reclaimed, not so much for economy, but to simplify the disposal problem.

Dollars that go down the drain in the form of chromium and cyanide in plating wastes can be recouped, a sanitation engineer advised, by keeping plating solutions clean so that tanks needn't be shut down for clean up, and tankfuls of solution. For example, sludge deposits in the tank may be eliminated by using demineralized water for solution make-up. Sludge deposits are said to stem from precipated carbonates brought in by the water. Distilled water solutions have held up for months without developing any sludge.

Under the general chairmanship of **P. H. Pretz**, the following served as chairmen of the six technical sessions of the SAE National Passenger Car, Body, and Production Meeting: **L. A. Danse, J. C. Widman, G. M. Buehrig, Lloyd Withrow, H. E. Churchill**, and **B. E. House.**

This report is based on discussions and 13 papers. . . . "Controlling Plating Department Wastes," by **D. E. Bloodgood**, Purdue University; "Disposal of Acid Wastes," by **J. E. Cooper**, Ford Motor Co.; "Removal of Soluble Oils from Waste Water," by **C. W. Hathaway**, Chevrolet Motor Division, GMC; "Smoke Abatement," by **L. C. McCabe**, Air Pollution Section, Bureau of Mines; "Coordination of Engineering and Materials Handling in the Fisher Body Division of General Motors Corporation," by **E. R. Frost**, Fisher Body Division, GMC; "New Developments in Glass," by **Robert A. Miller**, Pittsburgh Plate Glass Co.; "Will the Four-Passenger, Shorter-Wheelbase Car Find a Better Place in the American Market?" by **J. H. Wells**, The Austin Motor Co., Ltd.; "Elements of Internal Combustion Engine Power," by **W. E. Lay**, University of Michigan; "Cylinder Performance-Compression Ratio, and Mechanical Octane Number Effects," by **S. D. Heron** and **A. E. Felt**, Ethyl Corp.; "Wheel Hop and Shake Characteristics in Front Suspensions," by **C. A. Tea**, Ford Motor Co.; "Ride Problems Caused by Secondary Vibrations of Rear Suspensions," by **V. D. Polhemus**, General Motors Corp.; "The Versatile Shoe Brake," by **C. R. Lupton**, Bendix Products Division, Bendix Aviation Corp.; and "What Have Disc Brakes to Offer?" by **W. R. Rodger**, Chrysler Corp. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in SAE Quarterly Transactions.**

Properties of ZK60 A Magnesium Extrusion Alloy*

What It Is: ZK60, produced by Dow Chemical Co., is a magnesium alloy containing about 5.7% zinc and 0.6% ziriconium. The ziriconium has a grain-refining effect which increases strength and ductility. These properties make ZK60 magnesium particularly adaptable to extrusion. To develop its maximum properties, a reduction during extrusion of at least 50 to 1 in needed. In the extruded condition, the alloy is designated ZK60, and in the extruded-and-aged condition, ZK60A.

Its Uses: This material can be used in aircraft structural parts—such as floor beams, wing spar caps, stiffeners, and wing fastenings. Its combined properties of strength, toughness, and notch-insensitivity also make ZK60 adaptable to parts such as truck and trailer floor sills, textile machinery, materials-handling equipment, and in other similar industrial and commercial applications.

Physical Properties of ZK60

Specific Gravity (75F)	1.83
Weight (lb per cu in.)	0.066
Melting Point	1175 F
Coefficient of Thermal Expansion (per deg F)	
65 to 212 F	1.4×10^{-5}
65 to 750 F	1.6×10^{-5}
Modulus of Elasticity	6,500,000 psi

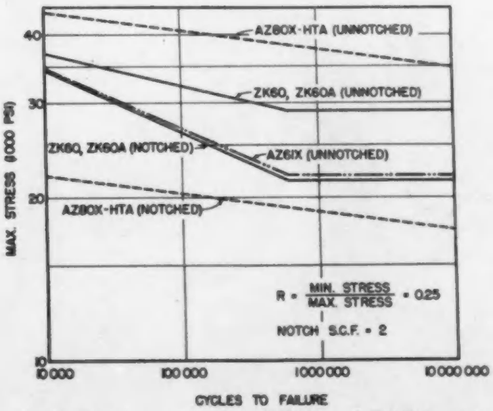
Shear and Bearing Strengths

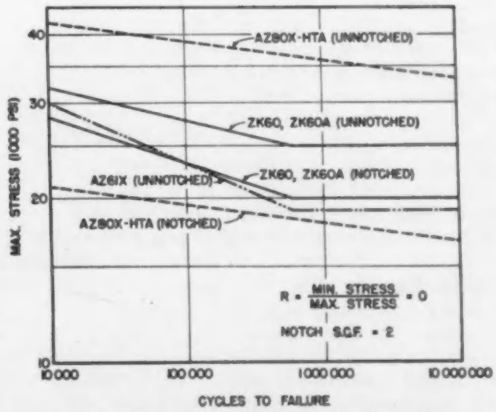
	ZK60	ZK60A
Shear Ultimate, psi	24,000	25,000
Bearing Ultimate, psi	73,000	76,000
Bearing Yield, psi	51,000	55,000

Representative Minimum Properties of ZK60 Magnesium Alloy Extruded Shapes**

DESIGNATION	CONDITION	SECTION AREA (SQ. IN.)	U.T.S. (1000 PSI)	T.Y.S. (1000 PSI)	C.Y.S. (1000 PSI)	EL. IN 2" (%)
ZK60	AS EXTRUDED	1.0	43	28	27	5
		1.5	43	28	27	5
		2.0	43	28	27	5
		2.5	43	28	26	5
		3.0	43	28	24	5
ZK60A	EXTRUDED AND AGED	1.0	45	30	30	5
		1.5	45	30	30	5
		2.0	45	30	29	5
		2.5	43	29	27.5	5
		3.0	43	29	25.5	5

** Minimum properties in this table can be assumed to hold up to 180 F. Above this, properties of ZK60 begin to fall off rapidly with increasing temperature.





How fatigue properties of ZK60 and ZK60A compare with those of the best commercial magnesium alloys

* From paper "ZK60: An Improved Magnesium Extrusion Alloy," by E. H. Schuette, The Dow Chemical Co., presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 8, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

A 7-Point Program For Fleet Operators

Based on paper by

H. O. MATHEWS

Standard Brands, Inc.

FLEET men will strike a sound balance in their operations by giving the proper emphasis to these seven steps in their program:

1. Select equipment which can be easily maintained.
2. Prepare broad specifications to create competition.
3. Make preventive maintenance work and keep changing to take advantage of new designs.
4. Use dealer service as much as practicable.
5. Select supervisory personnel to get best results.
6. Make records of reports pay their cost in improving results. Don't keep superfluous records.
7. Keep working on vehicle retirement programs to improve the total cost.

Although much has been said about selection of equipment, little has been mentioned about selection for economical maintenance. If manufacturers are to correct designs which result in costly maintenance, then operators must analyze new designs and work with the designer for prompt correction.

Afterthoughts Costly

For example, one popular passenger car lacks so insignificant an item as an ash tray. Because of this missing item, we have paid for seat covers and upholstery repairs. Interestingly enough, dealers could not get the parts to make this installation on standard models.

Specifications always should be broad enough to permit competitive bidding for the business. By buying only one make of vehicle fleet owners adversely affect their maintenance costs. There's another advantage in dividing business among manufacturers. Service departments of vehicle makers, who have only a part of a particular fleet, have more interest in helping minimize operating costs than one who has all the business.

Most important part of the fleet program to the ordinary operator is actual maintenance of the vehicle. Preventive maintenance really is the key to successful fleet operation; yet despite all that has been said, there are some operators who do not place enough importance on this item. Methods and schedules decided upon largely predetermine maintenance costs. The thing to decide upon is frequency of inspection and adjustment. No formula other than experience can be applied to fit a particular operation.

In one case, mostly by trial and error, it was decided to change lubricating schedules on small equipment from 1000 to 1500 miles, and oil changes were increased to 4500 miles on equipment with oil filters. While this change was minor in itself, the entire preventive maintenance program was adjusted to it.

Point four in the seven-step list raises the age-old controversy of dealer

Valves That Turn Are Tough to Burn

Based on talk by

A. L. POMEROY

Thompson Products, Inc.

MECHANICAL means of augmenting valve life—such as valve rotation—merit serious consideration, today as never before. It is getting harder and harder to create new alloys to withstand the mechanical and thermal stresses of present-day engines. Metallurgy is no longer able to meet the problem as in the past.

Rotating valves offer at least three important benefits. First, the stem will be free of deposits. This prevents sticking, a common cause of valve burning.

Second, rotation imparts a light wiping action between the valve face and seat, making for cooler operating valve heads. Preventing such face deposits also precludes the flaking off of some portions, which would allow blowby and subsequent burning.

Third advantage with valve rotation is that it prevents prolonged exposure of any one sector of the valve face to a local hot spot on the seat. This produces lower and more uniform valve-face operating temperatures. Reducing peak valve temperatures substantially improves valve life.

Appearance of rotated valves after thousands of miles of operation reveals their effectiveness. The stems are cleaned and polished, and faces and seats virtually free of deposits. This is illustrated in Fig. 1.

Among the secondary benefits of valve rotation are the prevention of stem scuffing. It distributes whatever lubricant there is around the valve stem diameter and prevents metal-to-metal contact, usually responsible for scuffing. Rotating the valve also cuts down undue tip wear and eliminates the grooving often found on non-rotating valves. (Talk "Valve Rotation," was presented at SAE Oregon Section, Corvallis, Ore., May 13, 1949.)

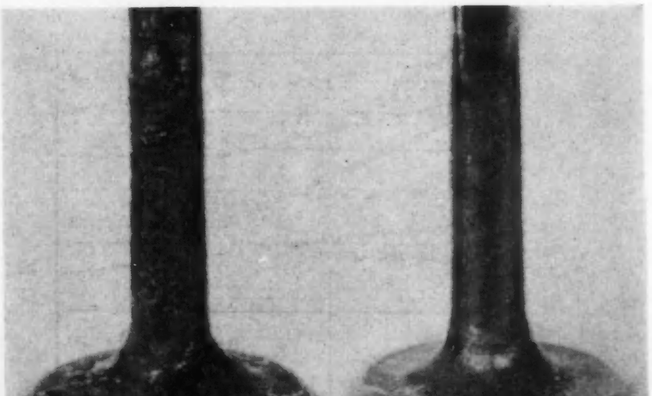


Fig. 1—Valve rotation contributes much toward alleviating valve sticking, burning, and deposit formation, as these valves show. The one at left is a standard valve that operated for 40 hr; the one at right is a rotating type that operated for 100 hr

service versus company shops. There are operations best suited to one or the other, while in some operations both should be used.

Bus and heavy-duty truck operators must establish their own shops to regulate their schedules properly and to guarantee continuous service for their equipment. Scattered fleets with small equipment (passenger cars and ½ to 2-ton trucks) should use dealer service as much as possible. It may be advisable to perform second echelon maintenance in metropolitan centers where cost of picking up and delivering vehicles, as well as labor, is excessive.

Personnel Reflect Supervision

But production, quality, and results of work from mechanics and service men will be no better than the supervision of the fleet operator's organization—in either company shops or dealer organizations. Efficient administration must be used to carry out policies and control fleet costs. Though representing the smallest part of the total costs, administration is most important.

For efficient administration of the operation, keep only those records that are essential, and make simplified reports which can be easily interpreted. Detailed records, such as tire mileage and oil consumption, cost a lot to maintain and depend on low-rate employees for their accuracy. Both these factors make their use questionable.

It has been found practicable to group expenses by type of vehicle, except where specific information is required. This results in a simplified report to management, which can be supplemented with appropriate comments to emphasize results.

Although most fleet operators do not control their vehicle retirement program (management fixes expenditures for new capital), the maintenance program must be regulated to fit the replacement program. But that's not to say that the fleet man should not make recommendations for vehicle replacement that will improve the overall fleet operation.

Retirement Policy

For example, the operator may be convinced that passenger cars should be replaced on an annual rather than a four-year basis. While the policy cannot be changed from four years to one in one step due to capital required, it may be possible to change from four years to three years life in one budget year, and then to try again another year. (Paper "Fleet Maintenance," was presented at SAE St. Louis Section, Oct. 11, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Lima-Hamilton's New Diesel Engine

Based on paper by

F. J. GEITTMAN

The Hooven, Owens, Rentschler Division, Lima-Hamilton Corp.

THE Lima-Hamilton four-cycle supercharged diesel engine, for switcher and transfer locomotives, is built in 6-cyl and 8-cyl models. The engine, in the switcher shown above, was designed to withstand stresses of 240 bmep. at 1200 rpm and 1800 psi firing pressure. It has a 9-in. bore, 12-in. stroke, operates at 950 rpm, and delivers 900 hp (6-cyl model) and 1250 hp (8-cyl model) at sea level. Following are some of the features that illustrate the engine's strength, accessibility and serviceability, and positive provisions for all engine functions:

•

The crankshaft is drop-forged, with uniform strength in the mains, webs, and crank pins, and generous fillets at all junctures.

•

Built for rigidity, the cylinder block consists of a top deck made of a 4½-in. thick steel slab running the entire length and width of the engine, 1¼-in. thick end plates, and ½-in. thick side sheets. Steel weldments are used throughout the engine.

•

Exhaust and intake valves are of the same length and interchangeable, so that the maintainer does not have to segregate them.

•

An intercooler between the supercharger blower discharge and intake manifold maintains the engine temperature level as low as possible. The intercooler also cools the exhaust manifold, keeping temperature of the exhaust to the supercharger between 900 and 950 F. Intercooler cooling medium is jacket water, which comes from the circulating water pump, goes through the intercooler, and into the engine intake header.

•

The Elliott Model E supercharger produces about 15 psi inlet manifold pressure. Though its designed speed is about 22,000 rpm, the supercharger is operated at about 17,500 rpm because of the intercooler and water-cooled exhaust manifold. This provides an extra margin of strength in the supercharger rotor.

•

Oversize bolts and studs are used wherever possible so that the maintainer need not be as cautious in tightening covers, heads, or housings as with small bolt or stud dimensions. Threaded holes in bearing shells, for inserting lifting bolts, are another maintenance aid. And it is not necessary to remove the heavy main bearing saddles, except in case of major calamity. (Paper "Design and Development of the Lima-Hamilton Locomotive Diesel Engine," was presented at SAE National Diesel Engine Meeting, St. Louis, Nov. 1, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Process Research Nets Gains in Manufacturing

Based on paper by

R. J. EMMERT

General Motors Corp.

TYPICAL of the improved manufacturing methods evolved by General Motors' Process Development Section are these three: (1) welding nuts to sheet metal, (2) tub polishing, and (3) electrical painting technique. (See p. 54 of this issue for article about this group's work in developing cut-wire shot for shot peening.)

The problem of welding nuts to sheet metal was submitted to the Section because nuts on back sides of fender skirts had a habit of disappearing during assembly. Although many people had worked out this problem, their solutions were costly as compared with cost of common square nuts. As Fig. 1 shows, costs varied from $11.00 per 1000 for a tee nut to $2.30 for the common square nut.

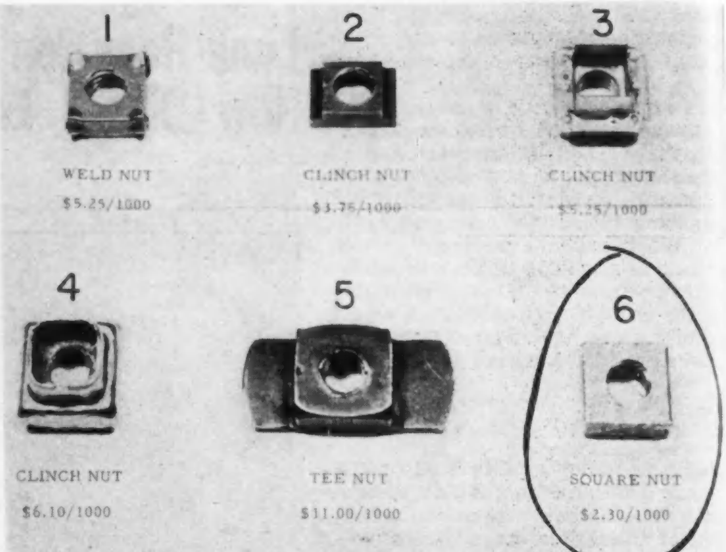


Fig. 1—Average prices for various 5/16-18 attached nuts were much higher than that for the common square nut. This provided the incentive that led GMC's development of a method of welding square nuts to sheet metal

The answer to sound welding of square nut to sheet metal was found through a special punch and die. As shown in Fig. 2, the punch and die punches the bolt clearance holes in the work piece and at the same time adds four projected dimples. These are formed by four pins in the punch collar and four holes in the die.

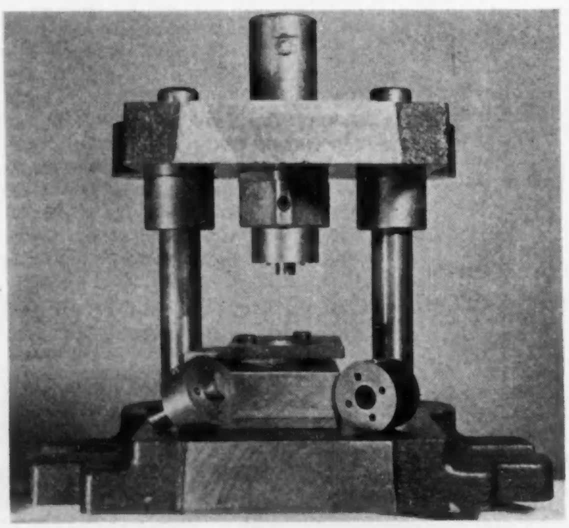


Fig. 2—Making possible the welding of common square nuts to sheet metal was this punch and die set, which dimpled the work piece while also punching the bolt clearance hole

The welding fixture has a locating pin that goes through the work piece and also guides the nut, which can be hand or hopper fed.

The second project—tub polishing and buffing prior to chrome plating—shows promise of replacing a dangerous, difficult, and time-consuming operation. Complicated parts such as grilles and bumpers have to be hand buffed prior to chrome plating. The machine in Fig. 3 can produce about 450 parts per hr, which is as fast as the operator can handle the parts. Here is how it works:

It consists of four fixture-holding columns, two tubs which revolve in opposite directions, and a water washing and abrasive recovery station. The four columns rise, index 90 deg, and push the parts down into the polishing material. When in this polishing material, or mud, the work-holding fixtures move through various angles to present all sides of the part to action of the mud.

The second tub rotates opposite to the direction of the first so as to polish the outer end of the part. Air jets blow the polishing mud off the part as it rises out of the tubs. Water jets rinse the balance off the part in the fourth position.

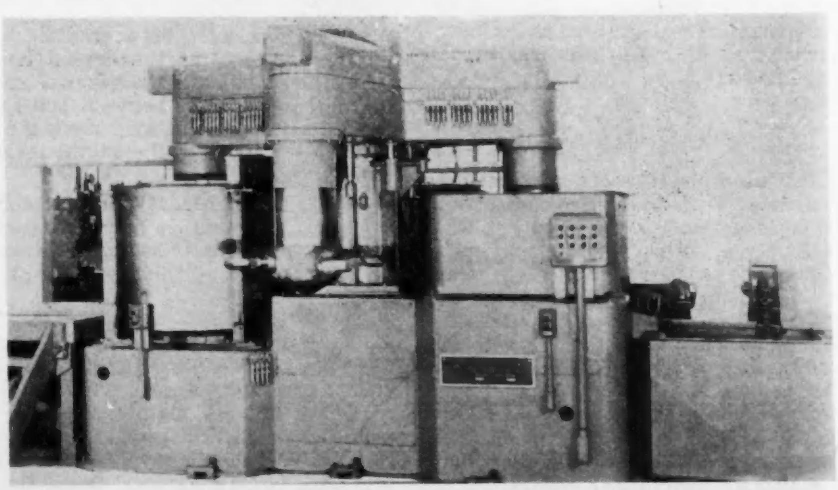


Fig. 3—This special four-station polishing and buffing machine replaces hand operations in preparing parts for chrome plating

Another method with many advantages, and still full of problems, being studied by Process Development is a painting process. Basic principle

the process is to put a negative charge on the paint globules as they emerge from the spray gun. This attracts them to the part to be painted.

Big advantage of the process is that it covers areas better and tends to coat the part completely. It requires little skill on the part of the spray painters.

But its problems are also big. Paint globules are not choosey where they go, as long as the destination is grounded. Paint booth, roof, floor, and conveyor as well as the part being painted get a goodly share of the paint. Also, the high air pressure at the gun and large volume of air used to atomize the paint tends to blow the paint past the work and into the water curtain. These two factors together with the high evaporation rates of the paint solvent also tend to dry the paint before it lands on the work.

Some paint pigments are long and narrow and land on the work like an arrow hitting a target. Thus the color has a different shade than when put on in the conventional way. (Paper "Process Development—The Link Between Engineering and Manufacturing," was presented a SAE Annual Meeting, Detroit, Jan. 10, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Road Roller Progress Noted

Based on talk by

MURRAY D. SHAFFER

Buffalo-Springfield Roller Co.

MANY features in current road rollers, as well as those in machines of the past, stem from developments of the Buffalo-Springfield Roller Co.

For example two new roller types for achieving smoother compaction more economically—the trench roller and the three-axle tandem roller—are Buffalo-Springfield designs. A new experimental machine under development is a vibrating roller, which consolidates soils at a far greater depth than conventional type rollers.

In 1893, the first machine built by Springfield overcame the defects of earlier steam tandem rollers, which left undesirable waves in the material rolled. The Company also designed and built the first gasoline-powered tandem roller.

Currently Buffalo-Springfield manufactures tandem rollers ranging in sizes from 1½ to 21 tons; three-axle tandem rollers weighing from 12 to 18 tons; three-wheel rollers of 5 to 14 tons; and trench rollers in a wide range of compressions. Available in 23 models, these rollers are used for compaction of lawns, sidewalks, driveways, plant floors, streets, highways, airport runways, dams, and embankments. (Talk "History of the Buffalo-Springfield Roller Co.," was presented at SAE Dayton Section, Nov. 10, 1949.)

Operator Pays Price For Diesel Engine Abuse

Based on paper by

WILMOT SANDHAM

General Petroleum Corp.

MANY operators think the diesel a temperamental creature. But its inconsistencies are largely a reflection of the operators' own deficiencies, a drain on their own pocketbooks.

Operators glow with satisfaction as the diesel purrs in a surge of power in response to throttle change. Yet they damn the engine when it balks, little recognizing that balking as a probable reflection of abuse or negligence in not doing the things necessary to keep the engine running. Here are a few examples of operator abuse and neglect and the price paid for them:

The Abuse: The zealousness of some operators to get more output leads them to tamper with the governor adjustment for higher rpm, or the smoke nut or rack bar to increase the fuel injected.

The Price: Maintenance expense will rise out of all proportion to the slight gain in horsepower secured.

The Abuse: Some diesel operators have been adding gasoline to diesel fuel with the mistaken impression that this will give them more power.

The Price: The rate of pressure rise increases so rapidly that cracked pistons, broken ring lands, blown cylinderhead gaskets, seized injectors, and cracked bearings probably will result.

The Abuse: In one case leaky fuel line connections to the injectors caused fuel oil to drip into the crankcase. The engine also was running with a worn fuel transfer pump.

The Price: Because the fuel oil was diluting the lubricating oil, the oil pressure was low. The worn pump made for low pressure to the fuel pump so that the diesel did not deliver enough power.

The Abuse: Some servicemen are overgenerous in filling the air cleaner bowl with new oil after cleaning it.

The Price: The extra oil offers more resistance to the air flow into the cylinders, reducing engine horsepower. Excess oil also may be carried into the cylinders and be partly burned, fouling up the combustion chamber. Too much oil can make an engine run away. This air cleaner oil burns as fuel, speeding up the engine; this speed of the air through the air cleaner, which picks up more oil, causing still higher engine speed.

The Abuse: Incomplete maintenance of the air induction system is one of the greatest causes of diesel ailments. In one case, the air cleaner was properly serviced, clean fuel used, and the injectors checked. Yet the down pipe leading into the air cleaner bowl was almost half choked off. The serviceman had failed to run a ramrod through the down-pipe to remove this accumulation.

The Price: The engine smoked and the driver complained of lack of power.

The Abuse: Failure to protect the exhaust pipe from road obstructions leads to mechanical injuries.

The Price: Big dents in the exhaust line increases the resistance against which the engine must push out exhaust gases. Since it takes horsepower to squeeze exhaust gases past these dents, engine power output decreases.

(Paper "Suggestions for Common Diesel Ailments," as presented at Sacramento Division of SAE Northern Calif. Section, Nov. 30, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Varied Devices Check Properties of Grease

Based on paper by

G. H. LINK

Shell Oil Co.

A wide variety of test equipment has been developed to determine automotive grease properties for both quality control and laboratory evaluation in developing new products.

For example, to determine the top temperature at which a grease can be

used, it is tested in a machine that measures its dropping point. Penetration testers measure consistency (hardness) of grease. And the ASTM grease worker, in conjunction with a penetrometer, measures the tendency of grease to soften or lose consistency under mechanical working.

Among the other test equipment described in the paper are the CRC wheel bearing tester, the oscillating friction machine, humidity cabinet, and cold room. The paper also discusses properties and requirements of automotive greases and tells about various types. (Paper "Automotive Grease—Its Properties, Requirements, Quality Controls, and Testing," was presented at SAE Metropolitan Section, New York, Nov. 17, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Guarding Against Dust In Tractor Intake Air

Based on paper by

W. W. LOWTHER

Donaldson Co., Inc.

TWO factors combine to give a tractor engine top protection from dust—a well-engineered air cleaner and air cleaner location in zones of lowest dust concentrations.

For best performance under all conditions, an air cleaner should be designed with most of these seven elements:

1. Adequate air capacity under all conditions of tilt and slop.
2. High efficiency under all ranges of air flow, oil levels, and temperature.
3. Compact size.
4. Low restriction or make for low horsepower loss.
5. High dust capacity.
6. Sturdy, leakproof construction.
7. Rugged, self-washing element.

If the air cleaner doesn't have adequate air capacity, dirty oil is pulled over into the engine from the air cleaner; the engine soon wears out; other virtues the cleaner may have are of little value.

Steady air flow makes for easiest control and circulation of air cleaner oil. But the cleaner must do its job under various conditions. For example, sudden engine acceleration tends to carry the oil higher in the element until good circulation can be re-established. And adequate oil control must be maintained under slop and angle operation.

Air cleaners should be calibrated for high efficiency not only at normal oil levels, but also with oil levels from ¼ to ½-in. high, and with air flows from idle to maximum air demand.

The cleaner should be as compact as possible because of limited space available for mounting it. Inlet and outlet sizes as well as passages through the cleaner should be large enough so as not to restrict unduly air flow, nor appreciably affect horsepower. In some cases the air ram effect of a long stack will overcome horsepower loss caused by air cleaner restriction and will slightly supercharge the engine.

Simplified Servicing

The cleaner must have ample dust capacity because the operator wants to service the cleaner only at specified times. The oil cup should have enough oil supply to keep plenty of fluid oil after its dust quota has been reached. Overall restrictions under these conditions should be close to the initial reading.

A leakproof air cleaner is a must because a leak in the induction system, including the cleaner, may soon ruin an engine. Not only are all dust particles abrasive—regardless of size, but a leak usually lets in a larger dust particle than would the air cleaner.

And if the cleaner is to perform satisfactorily throughout the tractor's life, it must have a rugged, self-washing element. If not, the restriction or horsepower loss will increase as more and more dirt is trapped.

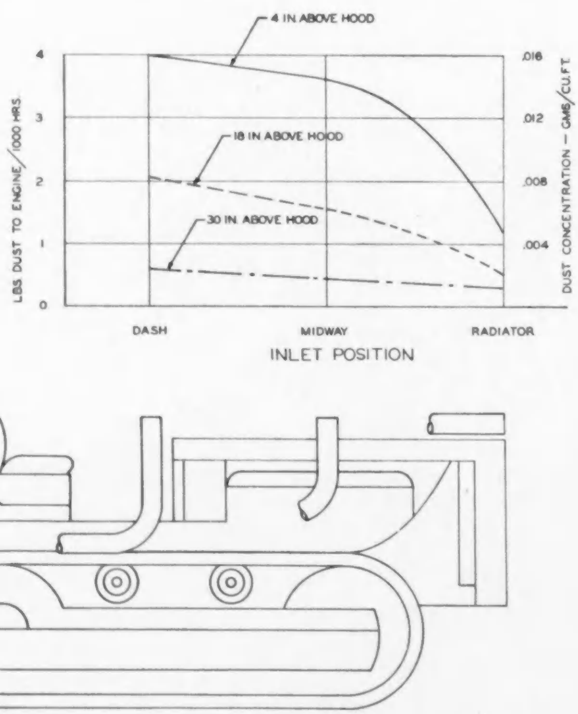


Fig. 1—The chart shows the effect of air cleaner inlet location on the dust intake of a 100-hp crawler tractor engine. Tests which produced these data were conducted under a condition of half-zero visibility

Location Significant

Second phase of the dust removal problem, air cleaner location, is best illustrated by data from tests on a crawler tractor. Although location of lowest dust concentration will vary with each tractor, the best location in this case is shown in the chart of Fig. 1.

Dust concentrations at various locations tested varied as follows: at dash, 0.016 g per cu ft; at 18-in. extension on air stack, 0.008 g per cu ft; extending air inlet forward to radiator top, 0.004 g per cu ft; and at 18-in. extension at front of radiator, 0.002 g per cu ft.

Here is what these locations mean in terms of engine dust intake. With a 99% efficient air cleaner located at the

dash, the engine takes in about 4 lb per 1000 hr. Locating the cleaner 18 in. above the top of the radiator cuts engine dirt intake 87%, or to 0.5 lb per 100 hr.

It will be a long time before that much improvement will be made in air cleaner efficiency. (Paper "Dust and Its Effect on Air Cleaner Design," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 14, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Urges Truer Appraisal Of Tool Tillage Forces

Based on paper by

PROF. A. W. CLYDE

The Pennsylvania State College

IT'S time that cut-and-try methods of designing workable hitches for farm implements give way to more rational methods. This calls for a knowledge of tillage forces (resistance which the tool meets when working in earth), their mechanics, and relationship to draft.

The paucity of knowledge on vertical and side forces on tools can be remedied by collecting data from properly conducted tests. One such test technique is to use six pressure cells to find the various components of soil force acting on the implement tool.

Mechanics Explained

Among the results such tests show (which some find hard to visualize) is that the total vertical force can be at some location away from the tool. Fact is that only the total soil resistance is fixed. At any point along its line of action it can be separated into components which produce the same effect. If one component is at a certain point, positions of all other components are fixed.

Another hard-to-see point is that soil resistance can include a couple or twisting effect. An analysis of the mechanics will tell us that real forces are scattered over the tool in many directions. No physical law says they must be combined into one resultant. With plows and discs, which roll soil sideways, they seldom can be combined into one.

One way of handling this is to combine them into two forces which do not intersect. Another way is to combine them into one force and a couple.

The paper also discusses effects of tillage forces on the tractor and analyzes one such typical problem. (Paper "Tillage Forces and Their Effects on the Tractor," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 15, 1949.) It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Lubes Researched In Fleet Service

Based on paper by

W. S. HOOCK

Sinclair Refining Co.

TEN years of testing heavy-duty oils in a city bus fleet proved that such work can be a valuable development research tool. It can provide practical data on sludge formation, bearing life, and parts wear if proper attention is given to operating variables, if test methods are controlled, and if standardized engine parts ratings are used.

In such work with a city bus fleet, tests were run using a new oil throughout the engine's entire life. The test is stated in a "newly built" engine, one equivalent to a factory-built product. Six units usually are used for each oil test.

Sampling Procedure

The test oil is used prior to engine run-in and for all charges and make-up throughout engine life. All oil additions are recorded. Oil samples are taken from the vehicle at 2000-mile intervals throughout the test run.

The test is completed when the engine is ready for overhaul. While the engine is being disassembled, each part is carefully examined and its condition noted. Deposit scores are assigned to individual parts according to the amount of varnish and sludge on each. Often photographs are taken so that ratings mays be standardized.

Wear measurements also are taken. Bearings and piston rings (weighed before start of the test) are reweighed. All inspection data are recorded on log sheets and later used for calculating the overall engine rating.

Condition of each part is rated on the basis of 0 to 10 (10 is clean, not worn or damaged, such as a new part; 0 represents a part with heavy deposits, or one that is inoperative or substantially worn out). Overall rating covers 0 to 10 ratings on four major items: (1) engine deposits, (2) pistons and rings, (3) bearings, and (4) cylinders and crankshaft. Top score is 0 to 40, which is multiplied by 2.5 to give the overall rating on a 0 to 100 basis.

During the 10 years that these tests have been made, more correlation was found between fleet tests and single-cylinder and full scale laboratory engine tests from a deposit standpoint than from wear. Relationship between fleet test results, laboratory bench tests, and analytical results was not always close. But oils with high performance ratings in fleet work excel in most ordinary laboratory tests.

The paper details the rating system for scoring the condition of each part. (Paper "Evaluating Lubricating Oil Through Fleet Tests," was presented at SAE National Fuels & Lubricants Meeting, St. Louis, Nov. 4, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Superchargers Used On New Diesels

Based on paper by

JACK H. GILL

and

R. S. FRANK

Caterpillar Tractor Co.

SUPERCHARGING is being used on an 8-cyl and a 12-cyl version of the new Caterpillar diesel engine because it seems to be the logical answer to the problem of getting maximum power per pound of engine to meet modern requirements of minimum weight.

A thoroughgoing study showed clearly that these requirements could be met if the amount of fuel burned in the engine per unit of displacement was increased as much as modern advances in materials, lubrication, fuel-injection equipment, and combustion-chamber design would allow. When more fuel is used, however, more air must be supplied to burn it, and it was found that not enough extra air could be drawn into the engine by natural aspiration—supercharging was needed to do the job properly.

To apply a supercharger to a line of engines that would be subjected to just about every known operating disadvantage presented no small problem. The supercharger had to function satisfactorily in stationary, portable, and marine service. It had to be

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CALENDAR

Atlanta Group—April 10

Town House Tea Room; dinner 6:30 p.m. Effect of Lubricating Oil on Engine Performance—J. W. Lane, manager, automotive division, Socony-Vacuum Oil Co., Inc. Social hour 6:00 p.m.

British Columbia—April 10 and May 8

April 10—Georgia Hotel; dinner 6:30 p.m. Meeting 8:00 p.m. New Ford Automatic Transmission — Harold T. Youngren, vice-president in charge of engineering, Ford Motor Co., Dearborn, Mich.

May 8—Georgia Hotel; dinner 6:30 p.m. Meeting 8:00 p.m. Development Work on Mufflers—L. H. Billey, engineer, Donaldson Co., Inc., St. Paul, Minn.

Buffalo—April 27

Norton Hall, University of Buffalo; dinner 7:00 p.m. Joint meeting with the University of Buffalo Engineering Society 8:00 p.m. High Speed Photography in Industry (illustrated with slides and movie film)—M. L. Sandell, Eastman Kodak Co.

Central Illinois—April 11-13

Hotel Pere Marquette, Peoria, Ill. Three-day Earthmoving Industry Conference includes five papers, four plant tours, and a banquet.

Chicago—April 11

Knickerbocker Hotel; dinner 6:45 p.m. Meeting 8:00 p.m. Six-wheel Trucks and Bogie Axle Suspensions—Robert T. Hendrickson, president, Hendrickson, president, Hendrickson Motor Truck Co., Lyons, Ill. Social half-hour 6:15 to 6:45 p.m. (sponsored by International Harvester Co.).

Cleveland—May 8

Automatic Transmissions—Joseph Geschelin, Detroit editor, Automotive Industries. Samples of transmissions, now or soon to be in production, will be available for inspection. Automobiles equipped with the various transmissions will be available for test driving.

Colorado Group—April 18

Thermal Efficiencies in Automotive Engines—Max Roensch, research coordinator, Ethyl Corp.

Detroit—April 24

Rackham Educational Memorial; dinner 6:30 p.m. What Industry Expects of the Young Engineer—A. T. Colwell, vice-president, Thompson Products Inc., Cleveland, Ohio. A Dynamic Day at Automotive Motors or Deep in the Jungle of Industry—Skit to be presented at the dinner by representatives of Detroit Section Student Groups.

Indiana—April 20

Purdue University, West Lafayette, Ind.; dinner 6:15 p.m. Octanitis–Alex Taub, director, Alex Taub Associates.

Mid-Continent—May 5

Ponca City County Club; dinner 6:30 p.m. Ladies Nite. Subject: Body Styling.

Milwaukee—April 7

Milwaukee Athletic Club; dinner 6:45 p.m. Engine Dietetics or Proof of Testing Petroleum Products—W. G. Ainsley, director, engineering laboratories, Sinclair Refining Co., Harvey, Ill.

Northwest—April 7

Gowman Hotel, Seattle, Wash.; dinner 6:00 p.m. Automotive Battery Construction—K. M. Ebert, vice-president, Laher Battery Products Co., Oakland, Calif. Cutaways and cross sections will be displayed.

Philadelphia—April 12

Engineer's Club, 1317 Spruce St., Philadelphia, Pa.; dinner 6:30 p.m. Meeting 8:00 p.m. Truck Performance—Actual versus Computed—Carl C. Saal, highway engineer, Public Roads Administration, Washington, D. C.

St. Louis—April 11

Bill Medart's Windsor Room, 7036 Clayton Road; dinner 7:00 p.m. Clutches, Now and Tomorrow—Harold Nutt, vice-president in charge of engineering, Borg & Beck Division, Borg-Warner Corp., Chicago, Ill. A cocktail half-hour sponsored by the Lincoln Engineering Co. of St. Louis will precede the meeting.

Twin City—April 12

Curtis Hotel, Solarium Room; dinner 6:30 p.m. Why Heavy Duty Oils —J. M. Miller, Standard Oil Co.

Wichita—April 27

Lassen Hotel, Ballroom; dinner 6:30 p.m. Recent Developments in Aerial Photography—Colonel Goddard, Wright-Patterson Air Force Base.

NATIONAL MEETINGS

AERONAUTIC and Aircraft Engineering Display	April 17-20	Statler, New York
SUMMER	June 4-9	French Lick Springs, French Lick, Ind.
WEST COAST	August 14-16	Biltmore Los Angeles, Calif.
TRACTOR	Sept. 12-14	Schroeder Milwaukee, Wis.
AERONAUTIC and Aircraft Engineering Display	Sept. 27-30	Biltmore Los Angeles, Calif.
TRANSPORTATION	Oct. 16-18	Statler, New York
DIESEL ENGINE	Nov. 2-3	Knickerbocker Chicago, Ill.
FUELS and LUBRICANTS	Nov. 9-10	Mayo Tulsa, Oklahoma
ANNUAL MEETING and Engineering Display	1951 Jan. 8-12	Book-Cadillac, Detroit

TECHNICAL COMMITTEE *Progress*

Technishorts . . . .

CARGO COMFORT: Just as poor vehicle riding characteristics can cause passenger discomfort, so bumps and vibrations can damage merchandise and equipment during shipment. For example, shock frequency and intensity may harm aircraft gas turbines and fragile automotive devices in transit. Ride vibration has been found to ruin certain types of fruit. The SAE Riding Comfort Research Committee has set up a subcommittee to study the shipping container impact problem, with R. W. Brown, Firestone Tire & Rubber Co., and Tore Franzen, Chrysler Corp., as a nucleus for the group.

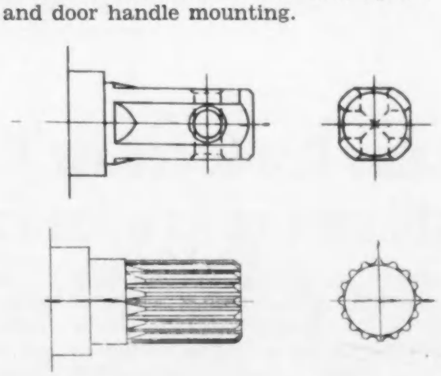
JET ENGINE ALLOYS: Rapidly increasing use of columbium for eliminating susceptibility of stainless steels to intergranular corrosion, and for increasing the strength of high-temperature alloys, has brought this metal into somewhat short supply. But fortunately, in many cases tantalum can be substituted in part for columbium. This is particularly true in the case of high-temperature alloys, such as those for jet engines, where numerous tests over the past few years have shown the effectivness of tantalum in maintaining strength at elevated temperatures. While further investigation is still necessary, favorable results of tests to date indicate the desirability of rewriting specifications for high-temperature materials and for some of the stainless steels so that they will include tantalum. This work is already under way in such groups as the SAE Aeronautical Material Specifications Division, which is revising its specifications.

CAR HANDLE STANDARDS: Dimensional standards have been developed by the SAE Body Engineering Committee for both the serrated and square types of window regulator handle and door handle mounting.

Right, above, is the square type, mounted with a cross pin.

Right, below, is the serrated type, mounted with a snap ring, screw in face, or set screw.

Dimensions are included for the cross pin and handle retaining ring as well as for the mounting and handle receptacle. These Standards have been approved by the SAE Technical Board for publication in the SAE Handbook.



MILLING CUTTERS: A proposed American Standard for Milling Cutters recently was approved by the SAE Technical Board. SAE as well as ASME, the National Machine Tool Builders' Association, and the Metal Cutting Tool Institute are co-sponsors of this Standard. If and when the proposal receives approval of all four sponsors, it will be transmitted to the American Standards Associations for final approval and identification as an American Standard. The proposed Standard, a revision of one issued in 1930, shows and describes common types of milling cutters, gives their nomenclature and principal dimensions.

Plane Brake Tests Set Up by SAE Group

A uniform method for evaluating brake installations on airplanes has just been issued by SAE. Outlined in SAE Aeronautical Information Report No. 29, Airplane Brakes—Field Test Procedures, this method calls for simple instrumentation and depends little on subjective reactions of the person conducting the test.

In the past, determining whether a brake installation is adequate was largely a matter of the test pilot's judgment. AIR No. 29 sets up more objective criteria for judging the suitability of brakes on a particular airplane.

Aircraft and brake manufacturers who reviewed this report before its final approval felt there is real need for such uniform procedures, that these methods could yield much valuable information.

Two Factors Studied

The report breaks down the procedures into two main categories—safe control and performance evaluation. It says that within their design capacity, the brakes should give safe control under specific conditions of static torque, deceleration, and taxiing. Also covered under evaluation for safe con-

trol are parking brakes, emergency brakes, and overload stops.

Performance evaluation specified in the report includes a check of pedal position, brake application and release, as well as tests for entrapped air and hydraulic fluid leakage. Salient conditions called for in the report are fully defined.

AIR No. 29 is available from SAE for 50¢. It was authored by SAE Committee A-5, Aircraft Wheels, Brakes, and Axles. Serving on the Committee are: W. H. DuBois, Bendix Aviation Corp., chairman; Pierce Hammond, Eastern Air Lines, Inc.; R. J. Keller, B. F. Goodrich Co.; H. H. Kerr, United States Rubber Co., R. E. Kibele, Curtiss-Wright Corp.; Charles Kitchell, Aerocar, Inc.; and F. D. Swan, Goodyear Aircraft Corp.

Ignition Men Are Saying . . .

MUCH remains to be done to the piston engine's ignition system to better the powerplant's performance. That's one area to which the SAE Ignition Research Committee devotes much of its activity, with particular attention given to spark-plug problems. Discussion at a recent Committee meeting pointed up need for such items as reduced plug fouling, a plug for high compression ratio engines, and plug ratings. Here is what some of the men at the meeting said about these items:

"Experience of airline operators and engine manufacturers alike indicates a real need for developing spark plugs suitable for high specific output aircraft engines. It is apparent that most currently available spark plugs will be marginal as present-day engines undergo their normal development to higher output and lower specific fuel consumptions."

Committee Chairman A. L. Beall
Wright Aeronautical Corp.

"Most inconsistencies in present spark plug rating procedures can be traced to the manufacture of the 17.6 rating engine. Manufacturing variations and design changes have been known to cause discrepancies in ratings as high as 40 imep. Rate variations of this order of magnitude do not necessarily prohibit the use of the 17.6 engine as an instrument; however, they do greatly handicap the exchange of information between various operators of this same equipment."

J. C. Johnson
Pratt & Whitney Aircraft
Division of United Aircraft Corp.

Five Electrical Standards Okayed

TWO new automotive electrical standards and three revised ones, developed by the SAE Electrical Equipment Committee, recently were approved for publication in the 1950 SAE Handbook.

The new Standards are:

1. SAE Standard for Braided Grounding Straps. Specified are the type of wire, strand size, and method of braiding copper battery and engine ground straps.

2. SAE Standard for High Tension Cable Synthetic Sheath (Waterproof Type). This specification covers 7-mm diameter cable used as ignition cable leads in motor vehicles or in tractor ignition systems. In addition to general physical requirements, the Standard spells out electrical, waterproof, life cycle, temperature, and oil tests.

The revised Standards are:

1. SAE Standard for Low Tension Cable. The revision includes the addition of thermoplastic-insulated cable, as well as two new cable types—Type 3, single braid, paper and type, and Type 4, double braided extra heavy duty.

2. SAE Standard for High Tension Cable (Braided Type). To this Standard, covering insulated cable for high tension leads in motor vehicle and tractor engine ignition systems, has been added a life cycle test.

3. SAE Standard on Electric Fuses. Some of the dimensions and test conditions have been modified in this Standard.

Status Quo Urged for Rating Antiknock of Aviation Fuels

DESPITE the need for an improved numerical system to express antiknock value of aviation fuels, the present rating nomenclature should be left unchanged. This is the studied opinion of the Aircraft Fuel Knock Rating Scale Group, of CRC's Coordinating Fuel and Equipment Research Committee, in its recently released report, "Method for Expressing Aviation Fuel Antiknock Ratings."

Present knock rating systems are confusing, says the report. There is one set of numbers below 100 (octane numbers), with iso-octane in normal heptane as the reference fuel, and another set above 100 (AN performance numbers), with tetraethyl lead in isooctane as the reference fuel. There is no way at present of extending the upper limit of the AN performance number system, which ends at isooctane containing 6.0 ml tetraethyl lead per U. S. gal (161 performance number).

The report points out a solution to the problem which would permit a single continuous numerical scale for expressing antiknock values. This scale, called the Detonation Index,

C. E. Swanson
Northwest Airlines, Inc.

"Since we changed from a fuel of 115/145 octane number and 4.6 ml of TEL per gal to one of 100/130 octane number and 3.0 ml TEL in our P & W 4360-powered airplanes, the lead fouling problem has been greatly reduced. However, at about the same time we changed to the lower octane fuel, we began to use carburetor heat and richer mixtures. Reduction of spark-plug fouling cannot be attributed with certainty to any one of these three changes. Quite possibly, the application of carburetor heat has as much to do with the lead-fouling reduction as did the change in lead content of the gasoline."

T. G. McDougal
AC Spark Plug Division
General Motors Corp.

"Spark plug manufacturers would like more space allowance for spark plugs. The hex size of the shell should be increased from ⅞ to 1 in. With the present hex size, it is practically impossible to design a demountable structure. Yet present indications are that this type of construction would be welcomed by overhaul personnel in view of cleaning problems and because no cleaning process, applied to the firing end of the plug, satisfactorily removes the deposits tightly packed—in some cases actually sintered—between the insulator and shell bore."

(Chairman Beall indicated this would call for removal of 30 to 40 sq in. of cooling fin area in some cylinder head designs to accommodate the 1-in. hex size spark plug and its wrench clearance.)

depends upon triptane in heptane at a constant tetraethyl lead concentration of 1.0 ml per Btu as the reference fuel system, and is extensible over a range of fuel quality considered completely adequate. Unfortunately, t ıptane is not available at a low enough price to be used as a reference fuel.

Therefore, the report recommends continuation of the present octane number and performance number ratings, together with their respective reference fuels, until a better answer is found or until the problem becomes more critical. For research and experimental purposes, when a test fuel exceeds the rating of iso-octane +6.0 ml tetraethyl lead per U. S. gal, the report suggests that its antiknock quality be expressed as a performance number determined from this expression:

Performance Number (above 161 only)

$$= \frac{\text{IMEP of test fuel}}{\text{IMEP of iso-octane} + 6.0} \times 161$$

In addition to a detailed discussion of these current and proposed antiknock rating methods, the report contains two extensive appendices. They are: (a) Army Air Forces Memorandum Report on Analysis of Aircraft Data Relative to Pursuit Fuels, and (b) CRC Report on Tests of LSMT and Leaded Triptane-Heptane Blends.

The report, CRC-241, has 82½ × 11 pages, including 17 tables and 35 charts. It is available from the SAE Special Publications Department. Price: $2.00 to members, $4.00 to nonmembers.

Superchargers

Continued From p. 75

able to stand extreme temperature conditions, salt air, dust, variable speeds and loads, and sudden speed changes. In some cases it would be subjected to a certain amount of abuse or neglected maintenance.

To meet these conditions, a modified Roots-type blower was chosen. To counteract the strain of sudden speed changes, the power train was designed to transmit power to the blower through a torsion shaft. The torsion shaft receives the power through a splined connection from a gear train on the rear end of the engine, where the torsionals in the crankshaft are at a minimum. The impellers are 2-lobed steel forgings with the shaft forged integrally with the lobes. The housing is heavy-ribbed cast iron. Since the steel impellers and the cast-iron housing have similar coefficients of expansion, the possibility of misalignment resulting from temperature variations is reduced to a minimum.

All bearings are of the sleeve type and are pressure lubricated from the main engine lubricating system. Piston-ring type oil seals are used on the impeller shafts.

The direction of rotation of the blower can be changed simply by interchanging the impellers. It rotates at 4912 rpm with a corresponding engine speed of 1200 rpm and handles approximately 1100 cu ft per min for the 12-cyl model. The blower for the 8-cyl model is identical with the exception that it is 3 in. shorter.

At 1200 rpm engine speed, the blower maintains slightly over 7 psi manifold pressure and provides, at all speeds, an abundance of air for maximum output.

For marine engine arrangements, where an abundance of cold water is available, an aftercooler is used to reduce the temperature of the air after it leaves the blower and before it enters the manifold. The air intake manifold is fitted with a steel tube provided with holes and slits opposite each cylinder inlet to dampen out the impulses generated by the blower. Angular inlet ports in the blower housing, together with air silencers installed ahead of the blower, reduce the usual high-frequency noises to a level suitable for all normal applications, including marine service. (Paper, "New Caterpillar Supercharged Diesel Engine," was presented at the SAE Annual Meeting, Detroit, Jan. 9, 1950. The complete paper is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers. Paper also describes many of the design features of the new engines, and is illustrated with photographs and performance curves.)

About

FRANK P. HERMAN, executive vice-president of Purolator Products, Inc., Newark, N. J. has been elected a member of the board of directors of the company. He joined Purolator in 1927 as manager of the Detroit office, later becoming equipment sales manager of the company. He was elected a vice-president in 1941, and became executive vice-president in 1945.

T. R. FARLEY, vice-president of Caterpillar Tractor Co., Peoria, Ill., has been named general manager of Caterpillar's new plant to be located two miles southwest of Joliet, Ill. He has had more than thirty years of experience in the manufacturing and merchandising of the company's products. The new factory will manufacture a large portion of the company's extensive line of bulldozers, scrapers, wagons, and rippers.

LESLIE R. PARKINSON, formerly in charge of the aeronautics option at Syracuse University, has been appointed chairman of the Department of Mechanical Engineering.

HARRY M. WILLIS, formerly chief inspector of Michigan Broach-Gear Division and Production Broaching Corp., Detroit, is now with Design Service & Sales Co., Cleveland, as echelon supervisor, Technicians Group, assigned to Corps of Engineers, Columbus General Depot, Columbus, Ohio. He is engaged in work relating to the Munitions Board Cataloging Program for unification of stock control of the various services.

T. F. BROWN, formerly general superintendent of the San Diego Transit System, San Diego, Calif., recently became owner and manager of White Truck Dealer, Yakima, Wash.

GERALD J. KUCHERA is a detailer in the Auto Control Arm Division of the A. O. Smith Corp., Milwaukee, Wis.

WARREN A. LIPMAN, formerly with the Cummins Engine Co., Inc., Columbus, Ind., is now with the Grumman Aircraft Engineering Corp., Bethpage, L. I., N. Y.

ARTHUR R. CONSTANTINE, formerly director of engineering for the Indian Motorcycle Co., Springfield, Mass., is proprietor of A. C. Research, Longmeadow, Mass.

CARROLL N. RILL, chemical director of Franklin Oil and Gas Co., Bedford, Ohio, has been elected a director of the company. He will serve as vice-president, directing the development and manufacture of metal working compounds and lubricants.

JOHN E. STERLING is service representative for the Buick Motor Division of General Motors Corp. at Boston, Mass. He was formerly service adjuster and claims manager for Buick, same city.

ROBERT M. BRAM has joined the Chance Vought Aircraft Corp., Dallas, Tex., as an aeronautical design engineer. He formerly held a similar position with the Goodyear Aircraft Corp., Akron, Ohio.

RICHARD JOHN NARAS has joined Joseph Naras Plumbing & Heating, Chicago, as estimator and manager.

LLOYD D. LARSON, formerly service manager for Hilo Motors, Ltd., Hilo, Hawaii, is now service manager for the McCoy Auto Co., Vancouver, Wash.

CONRAD L. BROSSEAU is district manager for the Mack Motor Truck Co. at St. Paul, Minn. He formerly held a similar position in the company's Indianapolis, Ind., district.

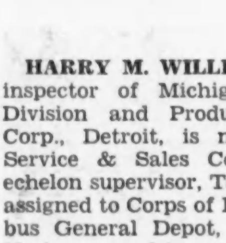
ROBERT M. COKINDA has joined the Lubricants Department of Shell Oil Co., Jackson Heights, L. I., N. Y., as assistant manager. He was formerly division lubricants engineer for Shell at Baltimore, Md.

V. L. BRANDT is proprietor of the Kelite Products Co., Portland, Oreg. He was formerly regional manager of the company.

ROBERT W. LAING is a project engineer with Caldwell & Associates, Independence, Mo. He formerly held a similar position with Smith, Hinchman, and Grylls, Inc., Detroit.

ARTHUR E. SLAGLE, formerly project engineer with Gulf Research & Development Co., Pittsburgh, Pa., is now service representative for Ford Motor Co., same city.

JOHN W. PAULI, formerly a fleet engineer with Ethyl Corp., New York City, is now a laboratory technician with Ethyl at San Bernardino, Calif.



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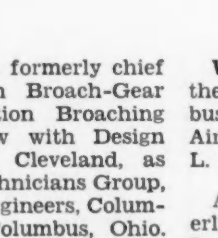

BERRY

WALTER N. DEISHER, vice-president and general manager, announced the appointment of J. H. BERRY to the newly-created position of director of manufacturing at A. V. Roe Canada, Ltd., Toronto. Berry will be responsible for the coordination and direction of all of the company's gas turbine and aircraft manufacturing activities

Members

COL. J. G. VINCENT, executive vice-president at Packard Motor Car Co., Detroit, is chairman of a recently established Operating Committee at Packard. The committee is composed of eight key administrative executives who will coordinate all top management functions. **W. H. GRAVES**, vice-president of engineering for Packard, is a member of the committee.

CLARENCE G. WOOD, who resigned last October as director of sales for the American Coach & Body Co., Cleveland, has recently been elected a member of the Board of Directors and vice-president of Karyall Body, Inc., same city.

CARL T. DOMAN has been appointed national service manager of a new and expanded service department of the Ford Division, Ford Motor Co., Dearborn. Scope of the department will be broadened to include many important additional functions.

R. F. MATHER has resigned as chief metallurgist of Kaiser-Frazer Corp., Willow Run, Mich., to become product representative, Stainless Steel Division, Sales Department, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

EDWARD C. WELLS, vice-president—engineering for Boeing Airplane Co., Seattle, Wash., in speaking of competition between the United States and Great Britain in the world market for jet and turbo-jet aircraft, said: "If we can build quality aircraft in a reasonable time at a reasonable price, we have a good chance at a share of the market. . . . "The British are more than competition (at the moment). They're alone in their field. . . . "But, I am confident we shall have better products when we have any."

A. J. AUKERS is now manager of industrial sales, Victor Mfg. & Gasket Co., Chicago. In his new position he will supervise the sales and product engineering for the company's manufacturers accounts.

ELLIS W. TEMPLIN, head of the General Plant Division's Automotive Engineering Unit, Los Angeles Department of Water and Power, was a member of the American Automobile Association Contest Board's technical committee for the Grand Canyon Stock Car Economy Run, Feb. 21-22. The contest is sponsored each year by the AAA and the General Petroleum Corp.

SAE members active in the Committee on Aeronautics of the Research and Development Board of the U. S. Department of Defense include four who have joined the Committee's organization recently, in addition to **PHILIP B. TAYLOR**, partner, Sanderson & Porter, who became its chairman last fall, and **J. D. REDDING**, who was named executive director on July 1.

The four who have been added to the Committee's organization recently:

RAYMOND W. YOUNG, consulting engineer, is a consultant to the Committee on Aeronautics and chairman of the Panel on Aircraft Propulsive systems.

PROF. E. W. CONLON, chairman of the Aeronautical Engineering Department, University of Michigan, is Cnairman of the Panel on Facilities.

ROBERT J. WOODS, chief design engineer of Bell Aircraft Corp., is chairman of the Panel on Aircraft Armament.

WILLIAM C. LAWRENCE, director of engineering, American Airlines, is chairman of the Panel on Aircraft Equipment.

JOHN F. CREAMER, founder and chairman of Wheels, Inc., New York City, was elected to the board of directors of General Tire & Rubber Co., Akron, April 4. He is a director of Clinton Trust Co. and the Greater New York Safety Council, a governor of the New York Athletic Club, and a trustee of the Automotive Safety Council, Washington, D. C. Creamer is a past-chairman of SAE Metropolitan Section.

R. S. ATKINSON has been appointed sales manager of the Romec Division, Lear, Inc., Elyria, Ohio. Atkinson, with 17 years sales and engineering experience in the accessory field, will direct the sales of Lear-Romec industrial and aircraft pumps and valves. He was formerly midwest sales engineer for the Pacific Division of Bendix Aviation Corp. in Chicago.

LESLIE PEAT left SAE Headquarters staff on April 1 to establish a management consulting service in public relations and industrial marketing. He will continue to handle SAE Public Relations as part of his new activity. With wide acquaintanceship and broad knowledge of activities in engineering areas, he will emphasize interpretation and application of technical products in automotive, aeronautic, and allied fields. His new service will be applied immediately in connection with Mercast Corp., which is licensing companies to use a new precision casting process which uses patterns of frozen mercury.

Formerly managing editor of "Automotive Industries," Peat came to the automotive field with wide experience in editorial executive positions on such newspapers as the New York World, the Cleveland Plain Dealer, and the Manchester Guardian. He has long been a member of the Governing Board of SAE Metropolitan Section and active in many phases of the Section's work.

T. A. KREUSER, service sales manager of Bendix Products Division, Bendix Aviation Corp., South Bend, Ind., was reelected president of the Automotive Electric Association by the Board of Directors of AEA at its 33rd annual meeting held in Chicago on Feb. 12.

JAMES R. BRIGHT has been named editor of Modern Materials Handling, Boston, Mass. Formerly managing editor of Product Engineering, he served in Army Ordnance during the war and now holds a reserve commissoin of lieutant-colonel. Before the war Bright was with General Electric Co. He holds a B.S. degree from Lehigh, and an M.S. in I. E. from Columbia University.

WARREN K. LEE, factory manager with Wilkening Mfg. Co., Philadelphia, Pa., has recently retired after 35 years in the automotive field. He is taking up residence in Florida.

PETER BUKOFF is now a project engineer with the Aircraft Landing Gear Engineering Section, Bendix Products Division, Bendix Aviation Corp., South Bend, Ind. He was formerly with the Airplane Division of Curtiss-Wright Corp., Columbus, Ohio, as an assistant project engineer and field engineer.

NATHAN WINARSKY is now sales manager for Diamond T of Newark, N. J., distributors of Diamond T Motor Trucks.

ROBERT S. PETERSEN has rectly joined the Link-Belt Speeder Corp., Cedar Rapids, Iowa, as a junior engineer.

GEORGE H. SCRAGG, for 12 years director of advertising and sales promotion for White Motor Co., Cleveland, has resigned to open his own sales promotion service agency with offices in that company's administration building. He started his engineering career with Santos Dumont in Brazil, was with Curtiss-Herring, Pfitzner, and Greene Aeroplane Co., and barnstormed on the Pacific Coast. He joined Mack Trucks, Inc., and in 1928 was asked to organize and head up the Cuban bus line Omnibus de la Habana, did consulting work in Spain and North Africa on transportation problems. In 1931 he became manager of national accounts for Brockway Motor Truck Co.

GORDON L. HOFFMAN, a recent graduate of the University of Colorado, has joined the Ace Box Co., Denver, as an industrial engineer.

RICHARD J. WILLS has joined the Sperry Gyroscope Co., Division of the Sperry Corp., at Great Neck, L. I., N. Y., as a field service engineer. He was formerly a test engineer with Pratt & Whitney Aircraft, Hartford, Conn.

FRANK G. STEWART, chairman of the SAE Washington Section was a member of the Automobile Show Committee which staged a 112-car automobile show in the Washington, D. C., armory beginning Feb. 18. He is president of the Standard Automotive Supply Co. in that city.

A. M. HAZELL, formerly manager, Automotive Department, Cudahy Packing Co., Chicago, is now with the company in Ohama, Nebr.

GEORGE S. GARRARD is now aeronautical design evaluation engineer, Power Plant Engineering Branch, Civil Aeronautics Administration, Washington, D. C. He was formerly a mechanical engineer with the CAA in Chicago.

R. R. TEMPLETON has recently joined the Power Plant Group of North American Aviation, Inc., Los Angeles, Calif., as a test engineer. He was formerly assistant division manager, Technical Data Division, Wright Aeronautical Corp., Wood-Ridge, N. J.

KENNETH P. BLACK is in the Engineering Department of the Vollrath Co., Sheboygan, Wis.

LAWRENCE T. APPELBAUM is a mechanical engineer with the Union Electric Co. of Missouri, St. Louis. He is a recent graduate of the University of Notre Dame.

REMEY COX, JR., has joined the Standard Oil Co. of California, Portland, Oreg.

FREDERICK W. HENNING, a recent graduate of Indiana Technical College, Ft. Wayne, Ind., has joined the Curtiss-Wright Corp., Columbus, Ohio, as a junior research engineer.

ROBERT L. PAPPAS has recently joined the Minneapolis Honeywell Regulator Co., Minneapolis, Minn., as a quality control engineer.

WILLIAM F. GOLISCH, a recent graduate of Lawrence Institute of Technology, Detroit, has joined the Picker X-Ray Corp., New York City, as a service engineer.

WILLIAM G. FISHER is a metal-cutting tool designer with W. F. & John Barnes & Co., Rockford, Ill.

HAROLD E. WEBB has been appointed sales engineer of Airborne

Equipment, Ltd., Los Angeles. He was formerly a manufacturers' representative with offices in Glendale, Calif.

J. BARRAJA-FRAUENFELDER, formerly consulting engineer of the American Locomotive Co., announced recently the opening of his office in New York City for consultations and project developments covering the internal combustion field in all its phases.

HERBERT J. WARD, is company engineer with Potlatch Forests, Inc., Lewiston, Idaho. He was formerly aviation ordnance engineer with the U. S. Navy at the U. S. Naval Ordnance Plant, Indianapolis, Ind.

JOHN M. RICHARDS has recently joined the Refinery Technology Division of Gulf Oil Corp., Philadelphia, Pa., as a junior engineer.

WILLIAM S. GLEESON has joined Thompson Products, Inc., Cleveland, as a junior test engineer.

EDWIN H. LAMPI, a recent graduate of the Aeronautical University, Chicago, has joined the Globe Rendering Corp., same city, as a mechanical engineer.

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OBITUARIES

WILLIAM O. McGUIGAN

William O. McGuigan, veteran of World Wars I and II, and president and general manager of Fryett-McGuigan, Inc., Yonkers, N. Y., died suddenly on Jan. 20. He was 50 years old.

An authority on automobiles and the automotive industry, he left school at the age of 15 to work at the trade, in the "horseless carriage" days. In addition to heading Fryette-McGuigan Inc., he was president of W. O. McGuigan, Inc., which has offices in Washington, D. C., and New York City.

McGuigan served as a private in World War I, and was commissioned a captain in the Motor Transport Corps, U. S. Army, in World War II. He did considerable work in activating new motor transport training schools and depots for the Army in all sections of the country. Assignments took him to the Holabird Quartermaster Center at Baltimore and in Washington D. C. He was attached to the office of the Chief of Ordnance and won a promotion to major in 1943.

After his discharge from the Army in 1945, he returned to his own firm, the Motor-Craft Co. of New York and Boston. The firm since has been renamed Fryett-McGuigan, Inc.

HENRY D. EISENGREIN

Henry D. Eisengrein, vice-president and general manager of the Ward La-France Truck Corp., Elmira, N. Y., died Feb. 15. He was 57 years old.

He was connected with the motor truck industry for more than 30 years, being associated with Maccar Truck Co., White Motor Co., Diamond T Motor Car Co., and Ward LaFrance Truck Corp.

During the war he was western representative of Ward LaFrance, with headquarters in Detroit. Immediately following this, he joined Diamond T as district sales manager for upstate New York and part of Pennsylvania. He left Diamond T to become vice-president and general manager of Ward LaFrance, at their plant in Elmira, N. Y.

DR. ALEXANDER KLEMIN

Dr. Alexander Klemin, educator and helicopter authority, died suddenly March 13 at his home in Greenwich, Conn., at the age of 61.

He was head of the Guggenheim School of Aeronautics, New York University, from its establishment in 1925 until his retirement in 1942. He was technical editor of Aero Digest at the time of his death, and a frequent contributor to other technical magazines.

Klemin was a member of the SAE Committee S-2, Helicopters, and wrote "Formulas for Determining Preliminary Performance Characteristics of the Helicopter," a committee report known as A.I.R. 27.

During 20 years of teaching he was always his students' personal friend and adviser, and kept in touch with the careers of hundreds of his graduates. He collected a huge galaxy of unusual engineering claims and patents, some of which "violated every known law of physics, but showed rich and fanciful imagination." He also had an enviable collection of scale aircraft models, many of which he built with meticulous care. Born in London, he was graduated from London University in 1907 with a B.S. degree. He received his M.S. degree from M.I.T. a year after coming to the United States in 1914. He became a U. S. citizen in 1917, and taught at M.I.T. and did research work for the Army Air Service during World War I.

Klemin joined SAE in 1916, and was a member of a number of other engineering organizations, including the Royal Aeronautic Society. He was the author of "Textbook of Aeronautical Engineering," "If You Want to Fly," "Airplane Stress Analysis," and "Simplified Aerodynamics."

Last January he was awarded the degree of doctor of engineering from NYU for his contributions to aeronautical education.

ERNEST L. WALTERS

Ernest L. Walters, research chemist for Shell Development Co., Emeryville, Calif., died on Dec. 6. He was 37 years old.

Upon graduation from the University of California in 1934, where he received a B.S. degree in chemistry, Walters joined the Shell Development Co., at Emeryville. He was employed there continuously except for the period September 1943 to February 1944 when he was with Shell Oil Co. at Wood River, Ill.

Walters had a wide experience in petroleum technology, having worked at various times with fuels, lubricants, and refining processes. In recent years, and particularly during the war, he specialized to a considerable extent in the properties of gasoline and was active in the war time coordination of gasoline stability studies. As leader of CRC groups investigating stability problems, he made a noteworthy contribution to the work carried on by the Coordinating Research Council for the military services and for industry.

He was an active outdoorsman, spending much of his free time on fishing and mountaineering expeditions.

LOREN M. KOLLER

Loren M. Koller, engineer with the Euclid Road Machinery Co., Euclid, Ohio, died last November in Cleveland after a brief illness.

He graduated from Case Institute of Technology in 1949, when he received the degree of B.S. in mechanical engineering. During the war Koller spent 30 months with a U. S. Army engineer combat battalion, serving one and a half years in Europe. He was 24 years old.

SAE Section Meetings

Premium Gasoline Often Poor Economy

• Washington Section

M. W. Snider, Field Editor

Feb. 21—"The great majority of automobiles on the road today will run as well and give the same power and gasoline mileage with 'regular' gasolines as with the more expensive premium grades," said **Jack Levedahl**, National Bureau of Standards engineer.

The main advantage in the so-called high-test fuel is its greater resistance to combustion knock. Resetting the distributor of a knocking engine will usually give a satisfactory reduction in knock with less than 1% loss in power and gasoline mileage. Use of premium gas is, therefore, often poor economy, Levedahl asserted.

Speaking on the "Relation of Octane Numbers to Engine Performance," Levedahl explained that an octane number is a measure of resistance of a gasoline to knock, and has no relation in itself to the amount of energy contained in the fuel. High octane gasolines are of great value because they make possible more powerful, more efficient engines. The most direct means of attaining higher efficiency is increasing the compression ratio. However, higher compression ratios cause an increased tendency of the fuel to knock. Consequently engine design is closely related to progress in petroleum refining technology. The engine compression ratio can only be increased to the extent permitted by the antiknock quality of the gasoline generally available.

In non-knocking combustion, Levedahl explained, the flame starts at the spark plug and moves evenly across the cylinder. This compresses and heats the mixture that has not been reached by the flame. With a low octane fuel a part of the unburned mixture often explodes spontaneously, causing a violent hammerlike impulse against the piston. This is usually accompanied by audible noise and in severe cases may cause overheating and engine damage with some loss in power.

Levedahl showed a slow motion moving picture of knocking combustion, taken with a researchers' camera at 500,000 frames per sec. These pictures showed that knock takes place in less than 1/40,000 sec.

Section Chairman Frank Stewart showed sound films of an automotive service show in Chicago.

Left to right: Past-President W. S. James, Fram Corp., a guest of the SAE Washington Section on Feb. 21; Section Chairman Frank Stewart, Standard Automotive Supply Co.; and the speaker, Jack Levedahl

Few New Cars Overseas Because of Costly Fuel

• Pittsburgh Section

Murray Fahnestock, Field Editor

Feb. 28—Substitutes are appearing for motor cars, particularly in France and Italy, according to **George A. Round**, chief automotive engineer of Socony-Vacuum Oil Co. He recently returned from a trip to England and Europe.

What's new in autos in Europe consists mostly of scooters and motor bikes, because of the high cost of fuel overseas.

Most important factor governing diesel engine design is the high cost of fuel. Conversation with a spokesman for London Transport, operators of over 7000 vehicles, convinced Round that diesel engine manufacturers have almost unanimously adopted the open combustion chamber design. With it, British engines are getting better than 9 mpg for double-deck buses and 11 mpg for single deck buses.

These engines use relatively poor fuels, of high sulfur content, with little smoke or odor. Round said the British engines were more powerful than U. S. designs, which burn special and better fuels.

Round showed how reduction of smoke and better efficiency in diesel bus engines were achieved by promotion of combustion chamber turbulence by means of shrouded inlet valves, squish-type pistons, and underrating engines.

Two foreign cars which impressed Round were a new lightweight Swedish auto with front-wheel drive, which was said to have remarkable riding qualities on rough roads, and a German Volkswagen, a light car with an aircooled engine at the rear.

PM, Repair Difference Stressed by Cumming

• New England Section

J. S. Walker, Ass't. Field Editor

Feb. 7—Fleet owners and operators save time and money by following a preventive maintenance program, said **W. J. Cumming**, manager, field service division, White Motor Co.

Cumming stressed the difference between PM (preventive maintenance) and repair, and emphasized that most PM services actually cost less than repairs after failure of a unit or part, and particularly if failure results in having a vehicle and load laid up on the road.

PM service schedules may be grouped and these groups adjusted to suit all types of operating conditions, and conducted on a mileage or time basis, said Cumming.

Leasing of Trucks Proves Advantageous

• Philadelphia Section

G. B. Calkins, Field Editor

Feb. 8—Characterizing his vocation as both fascinating and profitable, **Raymond A. Munder**, vice-president of Yellow Rentals, Inc., described "The Truck Rental Business" to an audience

Continued on p. 90

. . . New SAE Student Branches

Academy of Aeronautics

Russell Posthauer, second from right, receiving the SAE Student Branch charter in behalf of the Academy of Aeronautics, LaGuardia Field, Long Island, N. Y., from SAE past Vice-President Harold R. Harris during commencement exercises Feb. 24. Posthauer is vice-chairman of the Academy's student group, the 30th to be chartered. At the left is Joseph G. Liscouski, Jr., faculty adviser, and at the right is Raymond R. Faller, Ethyl Corp., the Student Activity Chairman of Metropolitan Section. This group has proved to be one of the most active among SAE Student Chapters, and has a membership of 139.

"You young men will find membership in the SAE a most valuable asset in your careers in aeronautical engineering," General Harris said in making the charter presentation. "It is one of the finest engineering societies in the world, and you will find the technical papers at SAE most informative and stimulating, and will meet the men who are leaders in this expanding industry," the general manager of American Overseas Airlines, Inc., said.

Tri-State College

"As young people you must restore some of the political, social, and economic freedoms that have long been accepted but are being lost," said Ralph R. Teetor, president of Perfect Circle Corp., when he was guest speaker at the presentation of the charter to the SAE Student Branch at Tri-State College, Angola, Ind., on March 1.

Technical progress, said Teetor, has not exceeded social progress, but to save the one thing that has made our country great, it is time for our technically trained men and women to take an active part in preserving these three freedoms.

Using his own piston ring manufacturing company as an illustration to show that incentive opportunities are responsible for the many technical advantages we have today, the piston ring manufacturer told how his father and uncle started the company with \$5700 and how it has grown to the \$8,000,000 project that it is today.

In presenting the charter, Teetor explained that the success of the automotive industry today has depended a lot on SAE.

"We could not have," he said, "the auto we have today at such a great saving if it were not for such an organization."

With plants in Hagerstown, Richmond, New Castle, Tipton, Ind.; and Toronto, Canada; Teetor has been active in many kinds of automotive engineering, ranging from railway in-

Speaker's table at presentation of an SAE Student Branch charter to Tri-State College included, left to right: Frank Acton, faculty adviser; Kenneth Parsons, chapter chairman; Bob Fessor, chapter treasurer; Ralph R. Teetor, speaker; and College Pres. Theodore T. Wood

Members of the new student branch who attended the dinner

25 Years Ago

Facts and Opinions from SAE Journal of April, 1925

Prominent representatives of the aviation industry met in New York on March 26 to consider how SAE could be more effective in aviation work. Valuable suggestions were contributed. A committee is to be chosen by the SAE Council with regard to the details involved. Present at the meeting were: Charles H. Colvin, H. M. Crane, F. G. Ericson, W. L. Gilmore, C. W. Hull, C. L. Lawrence, A. T. Loening, G. J. Mead, G. B. Post, C. M. Vought, E. P. Warner, and P. G. Zimmermann.

■

Nearly 4500 of the 5445 members listed in the 1925 Roster are located in 11 states: New York, 934; Michigan, 915; Ohio, 610; Illinois, 474; Pennsylvania, 358; Indiana, 251; New Jersey, 227; California, 207; Massachusetts, 201; Wisconsin, 158; and Connecticut, 117.

■

At the March Indiana Section meeting, several cars were demonstrated in which recently-developed power-transmission mechanisms were embodied. Many slides of the Weiss transmission were shown by E. B. Sturges. . . . E. O. White, Warner Gear Co., said the Patent Office is full of patents covering automatic and mechanical gear-shifting devices, which fall into two general classes:

(a) Those that operate on the down-stroke of the clutch pedal, the gears being positively neutralized and re-engaged by the power of the operators leg, the cycle of operation being complete when the pedal reaches the floor; and

(b) Those in which the down-stroke of the pedal neutralizes and the gear selected is pulled into mesh on the back-stroke of the pedal, either by the clutch spring or by an auxiliary spring.

■

At the March Washington Section meeting, S. W. Sparrow, Bureau of Standards, defined crankcase-oil dilution as the addition to lubricating oil of some liquid which will mix completely with it and reduce its viscosity.

■

Most of the work done on superchargers for airplanes by the Engineering Division, Army Air Service, has been with the exhaust-driven type, as this type appears to possess the greater advantage both from the mechanical and the thermodynamic points of view, E. T. Jones, chief of the powerplant section, told the Dayton Section on March 11. Jones, believes, however, that the direct-driven type will prove useful for intermediate altitudes, as this type can be made lighter and requires less modification of the structure of the airplane when the supercharger is installed.

■

As a result of the first joint conference held at the Philadelphia Naval Aircraft Factory on June 28, 1924, between the Army Air Service and the Bureau of Aeronautics of the Navy Department about 50 standards have been approved officially as AN or Army-Navy Standards.

■

"Trucks are overloaded habitually," says Ethelbert Favary, "and an excessive load on the tires ruins roads very quickly. To carry heavy loads and safeguard the roads at the same time, the six-wheel construction has made its appearance and is a much discussed topic."

■

In discussion of a production meeting paper by L. A. Churgay of General Motors:

Question: You think there is no difference between a salvaged tool and a new tool?"

Answer (by Churgay): No. If the salvage department felt that it could not salvage the tool properly so as to make it serve and look like a new tool, salvaging would be discontinued. It would make a poor impression on the shopmen if they knew they were working with salvaged tools.

■

"Many of the most serviceable and valuable instruments and laboratory setups are constructed from miscellaneous material, using a screw driver and a pair of pliers with a generous mixture of ingenuity. It is often undesirable to expend relatively large sums of money cn instruments that are used for a short series of observations only, and that can be constructed in homely fashion with the minimum expenditure of time and funds. Flawless finish is impressive but is often unjustified"—John A. C. Warner, SAE Research Manager in paper titled "Instruments for Automotive Research."

spection cars, to automobiles, engines, pistons and piston rings, and ship building.

Charter for the student affiliated chapter at Tri-State was approved at SAE Annual Meeting in Detroit last January. When the group attended the convention with their adviser, Frank Acton, professor of mechanical engineering, the group was recognized as one of the 10 largest student branches of the society.

Ken Parsons, chapter president, acknowledged the charter upon its presentation by Teetor.

Northrop Aeronautical Institute

On Feb. 3, 180 members toured the General Motors Buick-Oldsmobile-Pontiac assembly plant in South Gate, Calif.

Before the tour, students were welcomed by Mr. Garraway, supervisor of the tour. He explained how the assembly plant operated and asked them to notice how General Motors makes use of time in the scheduling operations. Unlike other automobile assembly plants where models of one make of car are assembled, this plant assembles all Buick, Oldsmobile, and Pontiac models on one assembly line.

At the frame line, the group saw the assembly of all parts that go underneath the frame. At the beginning of the main production line, the frames are uprighted and the first item installed is the engine. From this point the cars take shape rapidly. A little farther down the line, the tires are installed, and still farther, the bodies were seen lowered from overhead and installed. At the end of the production line, the cars are driven off to the testing section.

The body and paint shops were toured next, and the body line followed to where it meets the chassis on the main production line.

—Joseph Toth, Field Editor

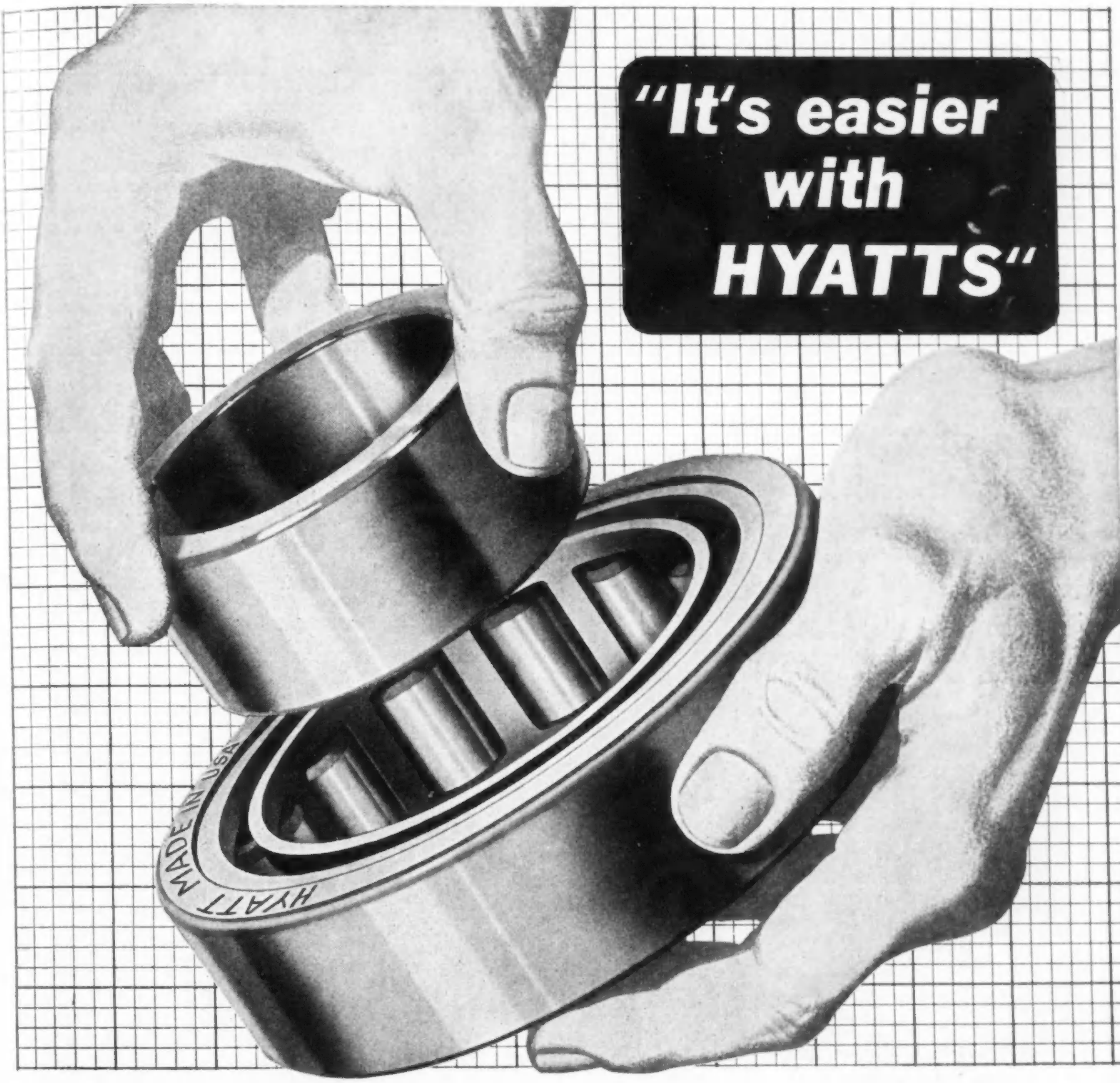
Lawrence Institute of Technology

When an automobile manufacturer produces more than one make of car, it is the aim of that corporation to achieve a distinctive style for each division and at the same time to employ the same dies wherever possible.

Kenneth Coppock, director, Experiment & Development Section, Fisher Body Division, General Motors Corp., explained at the Feb. 17 meeting that this result is achieved by permitting each division to design its own front end, fenders, and other parts, while employing the same body style for all divisions.

In operation, the General Motors styling section obtains its ideas for the models from "dreamers"—men whose sole responsibility is to design a car which presents a pleasing appearance, without regard to the practical aspects of manufacturing or operation.

In designing the car, perspective



To Cut Assembly Cost

HYATT Hy-Load Roller Bearings are precision products—all separable parts are so accurately made that any inner race or outer race will fit any roller assembly of the same piece number. This eliminates selective fitting and cuts cost on the assembly line.

Automotive engineers prefer Hyatt Hy-Loads, not only because of these assembly line advantages, but because they know from experience that Hyatt design and quality add smoother operation and better road performance wherever they are used.

Everywhere you look, cars, trucks and buses are rolling on dependable Hyatt bearings. Play safe, capitalize on the experience of the automotive leaders. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey; Detroit, Michigan.

HYATT ROLLER BEARINGS

sketches are made by artists, after which full-size blackboard drawings are made to achieve a satisfactory overall body design. Clay models of this design are then made and are criticized by the top management, sales section, and other interested departments.

After the inside positioning and dimensioning has been done, a plaster replica of the clay model is made with a finish that causes it to resemble the true car. This model is again subjected to criticism, and after all suggested changes have been made, the final design is approved and sent to the Fisher Body Division.

Each division of the General Motors Corp. has a separate design room from which members of all other divisions are excluded. Coppock said that this separation results in intense competition between divisions and eliminates all outside influences which might bring about a similarity of results.

Great care must be exercised to produce a style that will be neither too extreme nor too far behind. This requirement is further complicated by the fact that stylists work three years ahead of current production and that the final design must be tailored to meet the demand of the public at this future date.

Coppock also showed motion pictures of the first automobile show ever held, and of the races so popular with early automobiles.

—R. J. Gavin, Field Editor

The Ohio State University

Hot rod clubs, in order to exist, must observe all safety precautions and courtesies of the road, Robert Stevens, of the local hot rod club, observed at the Feb. 9 meeting.

Much ingenuity is involved in the rebuilding of an automobile to obtain peak performance and speed. The expense involved is considerable and for this reason most of the members attempt to do their own machining to obtain a higher compression ratio, advance of valve opening and closing, a higher valve lift, and greater valve port areas. The problem of going to higher compression ratios is limited by the expense of having to use alcohol injection, above about 9:1 compression ratio, and by the physical characteristics of the head and bearings.

Many companies throughout the country specialize in supplying reworked parts for stock cars. (One company supplies five different camshafts for each stock motor manufactured. They range in function from the stock camshaft to the high-speed racing type camshaft.)

The speed record for hot rods, held by the driver of a car using a reworked Cadillac engine, is 193.6 mph. It was pointed out that a hot rod is good for only one race and must be torn down to repair bearings, rings, and other warn parts after each race.

This hobby is expensive, time consuming, and at times discouraging, but the members apparently feel that the satisfaction of turning out a "rod" capable of speeds in excess of 120 mph is well worth the troubles involved.

—W. A. Staats, Field Editor

Rensselaer Polytechnic Institute

Sparks flew Feb. 9 at a demonstration of a new high-frequency ignition system for automobiles. Donald C. Peroutky, inventor of this radically new ignition system, explained in detail the principles of its operation and backed up his claims with an actual working model.

Peroutky pointed out that present-day ignition systems have certain inherent faults which are very hard to correct. Using diagrams to compare his new high-frequency system with a conventional installation, Peroutky showed the basic differences between the two. The design limitations of his new system, he explained, were that it be adaptable for use with a regular 6-v battery and standard spark plugs.

An explanation of the reasons for the superiority of high-frequency over conventional ignition followed. Peroutky showed how the voltage in a conventional system drops with increasing engine speed, as contrasted with high-frequency ignition, voltage of which remains constant over a wide speed range.

Other advantages of high-frequency ignition are that it will fire fouled spark plugs; its spark has a lower energy content, resulting in longer plug life; its timing is built in; no breaker points are used; no adjustments are necessary during the life of the engine; and the spark is better for cold-weather starting, when battery drain is heavy.

The demonstration set-up, containing complete ignition systems of both types, showed clearly the superior qualities of high-frequency ignition for automobiles.

The only disadvantage of Peroutky's system is one he discovered when he installed high-frequency ignition in his Nash—it interferes with radio reception. Yet he is confident that a power-supply filter will eliminate this difficulty.

Peroutky, a graduate of the University of Wisconsin and of Union College, is an engineer at the General Electric Co., where he is engaged in design and

development work on aircraft ignition systems.

—E. D. Vosburgh

Northrop Aeronautical Institute

The use of fiberglass in aircraft was discussed by Mr. Lampman of Northrop Aircraft, Inc., on Feb. 16.

He gave a short history of plastics dating back to 1909.

Lampman stated that plastic materials are available in standard forms, such as molding sheets, rods, tubes, reinforcements, and extrusions.

After an explanation of the molding processes used, with the advantages and disadvantages of each, he discussed the intricate process of weaving fiberglass to obtain fine fibers. The finer the fibers, the stronger the plastic, he said.

The students learned that a major problem is that of overcoming raindrops. Raindrops cause particles on the surface to disintegrate, thus weakening the part to a critical extent and leaving a rough surface. Surface roughness of fiberglass is not as smooth as that of metals.

The most important advantage of fiberglass, declared Lampman, is that any form or shape can be made. Other advantages are that it is usable for anything with compound curves. Such parts can be made in a few hours, and repairs can be made very easily.

Some of the disadvantages mentioned by Lampman are the difficulties in obtaining uniform stress distribution and joining, and insufficient strength in fiberglass for air inlet shocks.

—Joseph Toth, Field Editor

City College of New York

Trend in automatic transmissions is toward use of torque converters, and chief item of interest to look for in future designs is how car makers will combine the converter with other elements of the transmission. Joseph Gilbert, technical editor of SAE Journal, speaking at the March 2 meeting, predicated this observation on the evolution of current self-shifting drives, which he described.

Also take special note of these factors in coming automatic transmissions, he continued:

1. Blading design aimed at reducing converter losses.

2. Simplification of control mechanism and auxiliary transmission devices.

3. Converter and transmission component design aimed at reducing manufacturing costs, along the lines of the blading (precision stampings) in the Chevrolet and Studebaker designs.

In describing how the seven automatic car transmissions now in production work, Gilbert explored their pros and cons as compared with the conventional synchromesh gearbox. It

boils down to this: For the greatly increased driving convenience with an automatic transmission, the car driver sacrifices some fuel economy.

But engineers are overcoming this shortcoming in some designs by locking out the torque converter in direct drive. In other words, the torque converter is made to work when it displays its special talent (torque multiplication from maximum to 1 to 1 ratio through an infinite number of ratios), and is rested for the job which mechanical gears can do more efficiently.

The students attending the meeting inspected and operated a working model of fluid coupling from a Chrysler Fluid Drive transmission, which was used to explain how the device operates.

Julius Blank, president of the SAE Student Chapter at CCNY coordinated meeting arrangements and introduced the speaker.

Ugo Volpi, Field Editor

Section News

Continued from p. 84

of men committed in various ways to the operation of commercial vehicles.

His customers' business activities proved to be one object of Munder's fascination. He declared it the happy responsibility of the truck lessor to know all about them, much as a successful architect must understand his clients' living habits. Seasonal production peaks, tight delivery schedules, and special handling requirements were mentioned as specific problems. To them, he said, the truck operator brings the accumulated benefits of his experience. He noted that his own company was currently experimenting with two-way radio communication as a further aid to effective handling of special transportation problems.

Though not claiming to represent a new business, Munder nevertheless pointed out that truck leasing really got on its feet during the last war. One obstacle to public acceptance, he said, was the stigma attached to rented equipment, an attitude also common in the early days of installment-buying schemes. Both financial arrangements, he added, are considered wholly respectable today.

In a six-point summary, Munder explained the advantages of truck leasing:

1. Where truck operation is a sideline to the owner's main business, it suffers from lowered efficiency. In contrast, when the job is turned over to "professionals," the released time, effort, and money can be put to work more productively.

2. Released investment funds—for truck, garages, and equipment—bring higher returns in the lessee's own business.

3. Leasing provides an efficient solution to the peak load problem.

4. Trucking costs are known beforehand, and known exactly. They do not go up and down with, for example, the condition of equipment.

5. The appearance and condition of leased vehicles is kept up to snuff as part of the contract, including maintenance, painting, and washing. "To all appearances," Munder declared, "the vehicle belongs to the customer."

6. Deliveries can be scheduled and maintained. Replacement vehicles are provided in case of breakdown.

Length of contract, special provisions, and basis of charge were some of the items Munder was called upon to discuss. Asked how damage to vehicles was handled by Yellow Rentals, he said they didn't "nickel and dime the customer to death," but did seek recompense for deliberate abuse. He added, however, that troubles of this kind were infrequent.

Rather implied than spoken was the whole question of relative cost. Was owner-operation actually more costly than renting? There appeared to be a need for more comprehensive breakdowns of operating expenses on both sides, to permit better comparisons. Munder attempted to clarify some of the cost accounting problems involved by describing several situations in which, through oversight, the operator was not assessing his costs accurately.

Better Engine Design Can Conserve Oil, Metal

• Western Michigan Section
R. F. Allison, Field Editor

Feb. 16—There is much room for improvement in the design of engines from the standpoint of fuel and oil economy and longer life, **O. D. Treiber** stated, in his talk "Engine Problems of the Future."

Treiber, consulting engineer with Hercules Motors Corp., has devoted a lifetime of effort to engine improvement in that direction.

Conservation of oils and metals has been too widely disregarded up to the present time, he believes, but will become increasingly important in future design and development. Improved lubrication and cooling could save millions of dollars lost annually due to prematurely worn out parts.

Crankshafts designed so that destructive vibration periods are raised to speeds above those in the engine operating range, instead of the present

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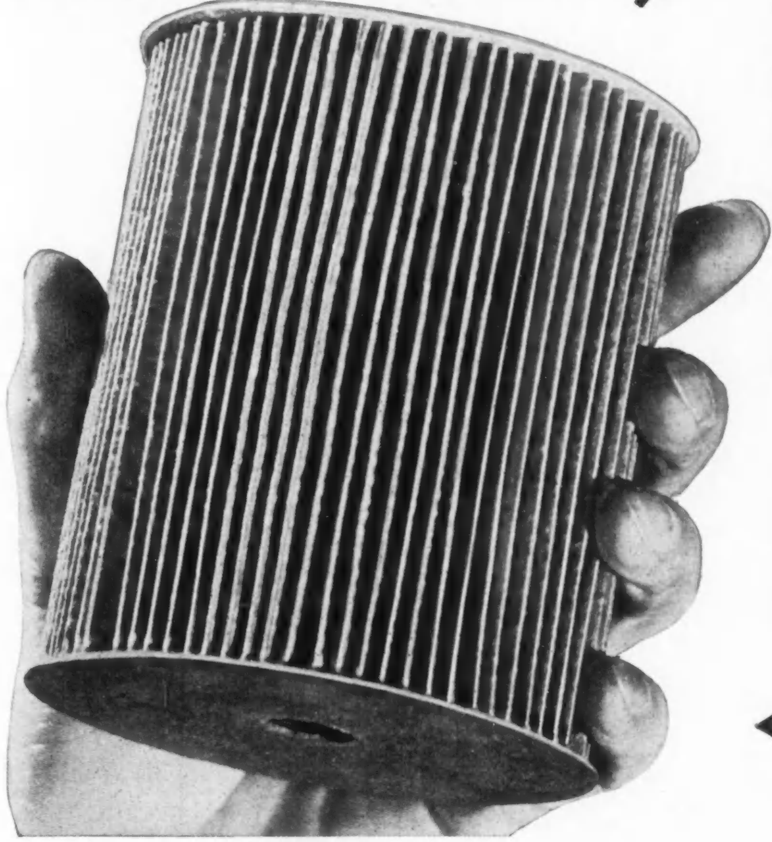

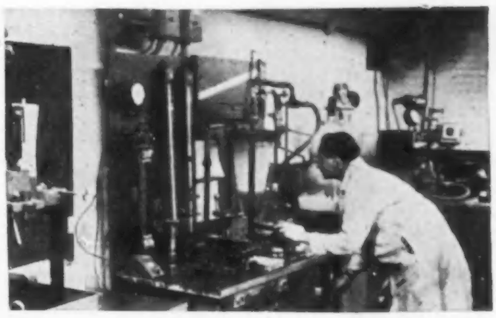

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practice of hanging a damper on the crankshaft to counteract some of the vibration are another valuable means to increase engine life. Treiber stated such a crankshaft had been designed in Germany during the war.

Citing the present rate of consumption of petroleum products of six and one-half million bbl. a day in this country, he contended that all possible means of improving fuel and oil economy should be fully investigated.

Compression ratios of 10.5 or 11 to 1 give the greatest efficiency he believes, and the present practice of using higher ratios in high speed diesels is largely the result of customers' requests for easier starting at relatively low temperatures without the use of auxiliary ignition aids.

During the discussion period Treiber criticized the somewhat loose usage of the word "detergent" by the oil industry in general, since there are so many different types of oil additives in use.

Concerning the use of alcohol as fuel, he doubted if the use of all the available waste vegetable growth could produce enough alcohol to greatly affect the total consumption of petroleum fuels.

Mohawk-Hudson Visits Brake Lining Division

• Mohawk-Hudson Group
A. F. Geiler, Field Editor

Feb. 15—Those attending this meeting were guests at the Marshall-Eclipse Division of Bendix Aviation Corp.

Following dinner in the company's cafeteria, a tour of the plant was arranged, showing the steps of brake lining manufacture.

Discussion followed the tour.

Wind Tunnel Tests Check Cars' Air Drag

• Metropolitan Section
J. D. Waugh, Field Editor

Jan. 19.—First results of wind tunnel tests of full-scale automobiles revealed in 20 years were presented at this meeting, by **L. H. Nagler**, technical advisor, Nash Motors, and **Prof. Kenneth Razak**, director, School of Engineering, University of Wichita, Kans.

The speakers employed slides, exhibits, and a motion picture to detail their scientific test findings on 10 different American-made, 1949 automobiles. A full array of modern aerodynamic apparatus was employed to check the pressure differences on differ-

ent parts of the cars, the skin friction, total drag, and the turbulence created by the body designs, in the Wichita wind tunnel.

Their research revealed that the 10 cars tested required on the average over 53 hp to overcome air drag alone at 80 mph. Certain body designs required only about 43 hp to achieve the same speed—an efficiency 20% better than the average due to better streamlining. The total drag of the car bodies was found to account for approximately two-thirds of the total power needed for driving a car 20 mph.

Some cars were found to use up to 51% more power than others in overcoming air resistance alone at all speeds from 30 mph up. The most efficient design improved fuel economy 2 to 3 mpg. The best streamlining was also found to reduce turbulence at the rear of the car.

Rear end turbulence was found to be more pronounced in cars with high-air-resistance designs. Bodies which taper smoothly from the top to the tail offered much less wind resistance than those which had jutting trunks, Nagler and Razak showed. A car with rear end turbulence developed a rear end shimmy at about 65 mph. Front wheel suspension and wheel unbalance were ruled out as causes of this behavior, and the authors concluded that air turbulence caused by poor streamlining in the rear was chiefly to blame for the shimmy as well as for the higher overall drag of certain designs.

Turbulent air flow started just above the back window on cars having a "bustle back" or "notch back" design. Certain cars with the so-called "fast back" styling had tapered designs in which the taper started too far forward and descended too rapidly, causing the airflow to break in the middle of the roof.

Fender-enclosed wheels had much less drag than the conventional open wheel well design. Exterior sun visors were found to increase wind resistance by about 10%. Streamlining the underside of test automobiles was found to decrease drag, but not sufficiently to justify the difficulty and expense of enclosing the underside on a production basis.

Summing up their results, the authors concluded: "These tests indicate the possibility of increasing car performance, reducing fuel consumption, and lowering wind noise by proper attention to aerodynamic characteristics of the exterior, without objectionable effects on styling."

Phil Pretz, of the Lincoln-Mercury Division, Ford Motor Co., discussed the Nagler-Razak paper in detail. He showed slides of wind tunnel testing of cars in the Ford tunnel in the prewar period and pointed out that this tunnel had greater clearance, hence less induced wind effect, than the Wichita tunnel. Pretz observed that large corrections may be needed to avoid magnifying the results obtained in tests where a car takes up about half the tunnel area.

He also stated that he believed that reduction of frontal area was of more significance in reducing air drag than differences in car body streamlining, in speaking of the "notch back" and "fast back" designs. Ford tests of these two designs did not uncover indications of streamlining superiority of either design. Ford preferred, for much test work, the results obtained by using a wheel torque meter under actual road conditions.

Pretz concluded: "Considering equivalent performance, frontal area, and customer average driving speeds; the economic difference in fuel saving from existing types of streamlining is considered very small. A most promising means of improving performance and economy at higher speeds is by reducing air drag. Wind tunnel work should be a reliable and relatively quick method of achieving improvements. It is suggested that accurate

correlation of tunnel and road results be established first. This may imply using larger wind tunnels or scale models."

Baltimore Tours Bendix Radio Plant

• Baltimore Section
R. L. Ashley, Field Editor

Feb. 9—A tour of the Bendix Radio Plant at Towson, Md. was featured at this meeting. E. K. Foster, general manager, and Bendix radio and engineering staff members were speakers.

The tour included factory and laboratory, covering radio, television, radar, and GCA.

The members also saw a movie on the Bendix ground controlled approach system.

New Scheme of Aids To Speed Air Traffic

• Kansas City Section
K. J. Holloway, Field Editor

Feb. 13—The four-course radio range which exists today will soon be obsolete, **Howard K. Morgan**, director of engineering, Kansas City Division of Bendix Aviation Corp., pointed out in presenting "Recent Advances in Air Navigation and Control."

The characteristics of the four-course range, in that it provides only four courses which may be followed to a point, necessarily limit the utility of this type radio range. Serious congestion on the airways and at terminal points would result when using such ranges with the volume of air traffic which is to be expected in the near future. Further, during thunderstorms the range of these low-frequency stations is limited to relatively short distances; but on clear nights the stations may be received at excessive distances, thereby causing interference and confusion.

The very-high frequency omnirange which will replace the four-course range will overcome the limitations mentioned above. Signals are transmitted from these stations, of which 300 are now in operation, through the full 360 deg. The VHF transmission from these stations is limited to line of sight but is not affected to any appreciable extent by thunderstorm activity.

Use of these ranges in conjunction with the radio magnetic indicator (RMI) and distance indicator (DME) enables the pilot to know the bearing and distance to the station at any time. Further, the pilot is able, by feeding certain elementary information into a computer, to pick out any point and fly directly to it without the necessity of flying over the station. A deviation indicator is also provided which magnifies the drift from the correct heading and simplifies following the selected course.

The instrument landing system (ILS) consists essentially of a glide path transmitter which transmits the path down the runway, and the receiving equipment and indicator in the airplane which indicate deviation from the glide slope and localizer beam. Marker beams are provided along the glide slope to indicate distance from the runway. This equipment enables the pilot to follow the intersection of

the beams down to the beginning of the runway.

Ground controlled approach (GCA) radar is composed of vertical and horizontal scanning screens which indicate displacement from the glide path and correct heading. All equipment is located on the ground and communication with the airplane is by voice. This equipment is planned for use with ILS, and as they operate entirely separately, the two systems may be used for monitoring each other.

It is also considered very important for the pilot to have a visual check during the last few feet of descent and the run on the runway. Bartow lights cleverly arranged so as to appear as bars to a pilot on course and as chevrons to a pilot off course supply this need.

Experiments with the FIDO system, which consists of large burners to raise the temperature of the air over the airport a few degrees to disperse fog, are also being conducted.

The complete scheme of air navigational and traffic control aids recently drawn up by an industry-government committee will cost somewhere in the vicinity of $1,113,000,000. Of this amount, $75,000,000 is allotted to development and the remainder for putting the system into operation. The complete system will improve the safety of instrument flight and will enable the completion of a larger per cent of scheduled civil flights as well as being of great value to the military services in time of national emergency.

Hawaii Section Hears Jakosky, Waterhouse

• Hawaii Section
Rene Guillou, Field Editor

Feb. 20.—Talks by **Col. Milton Jakosky** of the Civil Aeronautics Administration and by **W. C. Waterhouse** of Murray Air, Ltd., followed a dinner meeting.

Jakosky pointed out that CAA is responsible for the administration of all federal regulation of civilian flying, the legislative and judicial aspects of such regulation being vested in the Civil Aeronautics Board. The CAB promulgates regulations and acts as judge when violations are prosecuted by the CAA.

Provision of flying aids is a function of CAA with which two-thirds of its 15,000 employees are engaged, according to Jakosky. Flying aids include visual and radio beacons, markers, and range stations covering 60,000 miles of airways; communication stations; and radar instrument landing systems. Of the marked airways 300 miles are in Hawaii. Due to generally fine weather and complete absence of fog, Hawaii has only one ILS installation, located at Hilo Airport, where a 200-in. annual rainfall from low clouds sometimes restricts visibility.

Turning to regulations dealing with competence of personnel, Jakosky reported that of 1200 accidents in a recent period, only three could be attributed to errors by mechanics. In two of these cases the mechanics were not graduates of approved schools and in the third case a defective aircraft repair was performed by an engine mechanic.

Jakosky commended the Honolulu Vocational School for its high standards of instruction in aviation mechanics and predicted that in the near future hundreds of students would come here each year from the Far East for this type of training.

Comparative importance of aviation in Hawaii is due to heavy air traffic, according to Jakosky. Present passenger travel on the 2400-mile air jump to the mainland is equal to the

capacity of 7 to 9 modern ocean liners in continuous service.

Speaking on "Agricultural Flying," W. C. Waterhouse reported that while spraying or dusting from the air has been thought of as a means of insect control, a large part of agricultural flying is now for the purpose of weed control by means of selective sprays.

Having started two years ago with a single plane, his firm now operates four planes and one helicopter. Waterhouse stated that the conventional planes carry heavier loads than the helicopter, travel faster, and cost less to buy and to operate. The helicopter, on the other hand, needs no landing strip for reloading, can be reloaded in less time, spends less time in turning at the ends of rows, and is better able to follow the surface of rough fields.

The down-draft of air from the helicopter has proved to be a disadvantage, according to Waterhouse, as it creates a turbulence which mixes the spray with an undesirably deep layer of air. It has been found necessary to use a coarser spray from the helicopter, in order to promote rapid settling and to reduce wind-drift.

Waterhouse prefers the helicopter for small, rough fields at a distance from a landing strip; for large, level fields not too far from a practicable landing strip the conventional planes are more economical.

Accessory Equipment Fits Individual Needs

• Chicago Section
P. P. Polko

Feb. 14—Economic factors and field operator's demands influence the design of construction and industrial machinery, began **J. M. Davies**, in his talk "The Influence of Accessory Equipment on Design of the Modern Track-Type Tractor."

Davies is director of research at Caterpillar Tractor Co.

Tractor accessory equipment is a workingman's tool which enables him to realize greater accomplishment or productivity with much less expenditure of time and labor, declared Davies. Today's large variety in allied equipment design permits wide choice of machinery for satisfaction of individual needs. The driving force which must be credited for the great progress in this field is the manufacturer's and user's ability to realize a profit.

While the track-laying tractor has been used for a half-century in providing power for big projects in earthmoving, construction, and agriculture, it was originally conceived only as a vehicle with which to pull. For many years tractor designers were opposed to hanging implements on their units so as to avoid severe operations for which the tractors had not been built, he said. But customers finally won their arguments on the great need for accessory equipment, and in 1930, tractor engineers swung to the other extreme to work hand-in-hand with allied equipment builders.

At first, declared Davies, serious marketing complications arose because of wide variance in accessory mounting provisions. Closer association between crawler-tractor manufacturers and auxiliary-equipment people has overcome this difficulty. The implement mounting standardization work conducted by SAE has been an important aid in simplifying accessories-to-tractor assembly.

More changes and more advancement have taken place in tractor and accessories design during the few re-

cent years in our United States than have been developed in all the rest of the world for many centuries.

With the use of Caterpillar equipment slides, Davies described the influence mounted accessories have had on basic tractor design. He spoke of how changing economic conditions have continually demanded higher work power and production from the combined equipment and tractor unit.

The development of several different types of tractor-mounted accessory equipment was traced by Davies, from their crude beginnings to their modern high performance counterparts. The slides and movies served to illustrate design and operation of bulldozers, rotary and carryall scrapers, excavators, loaders, arch-logging outfits, rippers, and pipe layers.

Pertinent comments relative to present-day coordination of efforts between tractor and accessory equipment engineers were made by G. W. Mork, chief engineer, Bucyrus Erie Co.

Lube Oils Improve In Past 15 Years

• St. Louis Section
G. C. Husbands, Field Editor

Jan. 17—Until 1935, the general trend in making lubricating oils was to remove the impurities and unwanted characteristics, said **J. W. Lane,** manager, automotive division, Socony-Vacuum Oil Co., **New York City,** in his paper "Development and Application of Modern Automotive Oils and Multiple Purpose Greases."

For the past 15 years, due to increased horsepower in the gasoline engine and the widespread adaptation of the diesel engine, lube oils and greases have been called upon to do a more difficult job.

Lubricants have been improved by the introduction of various additives which allow a better flow when cold and yet retain good body when hot, said Lane.

In concluding, Lane declared that oxidation has been reduced at higher temperatures and the ability to do a better job has been accomplished.

Gold Comet Reo Engine Described by Johnson

• Northwest Section
K. A. Short, Field Editor

Feb. 10—There are many outstanding features on the new Gold Comet Reo engine, said **R. W. Johnson,** service engineer, Reo Motors, Inc., Lansing, Mich. These include:

Wet cylinder sleeves of alloy iron, with synthetic rubber seals, which can be installed with thumb pressure;

Intake manifold integral with cylinder head, with water jacket around it;

Exhaust manifold of entirely new design to minimize back pressure;

Stainless steel heat control valve; and

Water gallery from pump to center of water jacket. This enables the water to flow forward, backward, and then upward to a graduated outlet manifold making possible very uniform cooling.

There is jet cooling around all exhaust valves, and main bearings and

connecting rod bearings are interchangeable.

Use of a hub instead of a flange for the flywheel mounting allows the use of a spring-loaded neoprene seal on the rear as well as on the front of the crankshaft.

The cylinder head is held down by fourteen 9/16-in. studs, which are accessible for tightening without disturbing the rocker shaft.

A new Houde viscous torsional vibration damper is also included.

Atomic Power Problems Described by Shrum

• British Columbia Section
J. B. Tompkins, Field Editor

Feb. 13—Automotive engineers who look to atomic power to solve many of their problems can bury their dreams, in the opinion of **Dr. G. M. Shrum**, head of the physics department, University of British Columbia.

Shrum promptly qualified his prediction saying, "since science moves so rapidly today, any predictions on the industrial applications of atomic power can be taken with a grain of salt."

Though he estimated that it would be at least 30 years before atomic power can compete with coal and other sources of energy, he pointed to a prediction made some four years ago that energy would "never" be developed from hydrogen. "Yet early this year, just four years following this prediction, Pres. Harry Truman announced the United States would build H bombs," he said. "But I can see no peacetime uses for the bomb!"

As a member of Canada's (Chalk River) Atomic Energy Commission, Shrum hit at those who cry for a halt in scientific experimentation with atomic and hydrogen energy. "There will be no war," he declared, "as long as we maintain our scientific initiative and engineering superiority."

"And besides," he quipped, "the H bomb won't obliterate civilization because civilized people don't live in such cities as Vancouver, Montreal, New York, or Chicago."

Atomic power can be controlled "very easily." With one atomic bomb equal in energy to 20,000 tons of TNT, Shrum said it was "technically feasible to produce atomic power. But is it economically feasible?"

He saw a future use of atomic power in very large plants and installations where it would be possible to erect the extensive protective shielding necessary. But he could see no installations in the foreseeable future of atomic powerplants in motor vehicles.

About SAE Members

Continued From p. 83

T. G. WHITENER is secretary, treasurer, and general manager of J & M Products Co., Dallas, Tex.

JOSEPH GESCHELIN, Detroit editor of Chilton Publications, has been named chairman of the Independent Research Committee on Cutting Fluids, whose postwar reorganization has recently been completed. The IRC has undertaken an ambitious program of special studies of particular interest and practical value to manufacturing plants. IRC reports, as completed, will be made available through the proceedings of various engineering societies. . . . Geschelin was recently interviewed on Station WJR (Detroit). Subject of the interview was the automatic transmission.

DAVID H. KAPLAN, formerly flight test engineer with the Piasecki Helicopter Co., Morton, Pa., has joined Doman Helicopters, Inc., Danbury, Conn., as a project engineer.

WILLIAM J. SKELLEY, formerly a draftsman with Aircooled Motors, Inc., Syracuse, N. Y., is now a draftsman with the NEPA Project of the Fairchild Engine & Airplane Co. at Oak Ridge, Tenn.

CHARLES H. COLVIN, vice-president and general manager of G. M. Giannini & Co., Inc., Springfield, N. J., received an award for "notable achievement" at the 80th Annual Alumni Dinner of Stevens Institute of Technology, Hoboken, N. J. Colvin graduated from Stevens in 1914.

WILBUR J. BOSSONE, formerly a production expeditor for Lockheed Aircraft Service, Inc., Sayville, L. I., N. Y., is now an instructor at the Academy of Aeronautics, LaGuardia Field, New York City.

RICHARD W. WINSLOW has recently joined the AiResearch Mfg. Co., Los Angeles, Calif., as a major preliminary design engineer. He was formerly project engineer for Continental Aviation & Engineering Corp., Detroit.

LEONARD M. CLUTTER is now a mechanical engineer with the RCA Victor Division of the Radio Corp. of America, Marion, Ind.

EDWARD E. GALEAZZI, a recent graduate of Lawrence Institute of Technology, Detroit, has joined United Geophysical, Kingsville, Tex., as an assistant surveyor.

DAVID L. HELLER has joined the Fairchild Camera & Instrument Co., Jamaica, L. I., N. Y., as an engineer. He was formerly with Texas Electric Service, Ft. Worth, Tex.

ROY P. TROWBRIDGE is assistant standards engineer with General Motors Engineering Standards Section, Detroit. He was formerly research engineer with the corporation's Research Laboratories Division, same city.

RICHARD M. OLIVER, formerly commanding officer on the USS Saipan, is now Naval Liaison officer for Guided Missiles for the Navy Department at Pasadena, Calif.

MAJOR A. HALLIDAY has recently been appointed transport manager to Anglo-African Timbers, Ltd., Kumasi, Gold Coast. He was formerly engineer transport officer, Government Department, Accra, Gold Coast.

CHARLES W. MacMILLAN, formerly a development engineer with the Ribbonwriter Corp. of America, Dania, Fla., is now division engineer, Manvee Division, Bear Mfg. Co., Rock Island, Ill.

New Members Qualified

These applicants qualified for admission to the Society between Feb. 10, 1950 and March 10, 1950. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

Charles F. Schwarz (SM).

Central Illinois Section

Robert A. Fletcher (A).

Chicago Section

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Wichita Section

John J. Nunemaker (M).

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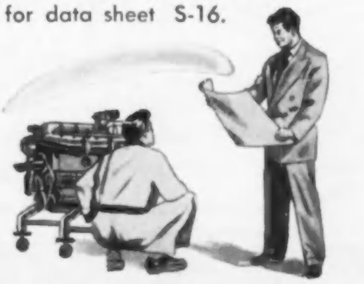

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Applications Received

The applications for membership received between Feb. 10, 1950, and March 10, 1950 are listed below.

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William L. Jones, Edward Barry Sleigh, Daynard McCall Welsh.

Canadian Section

Wallace Gordon Brown, Richard A. Cadieux, Ashton A. Calvert, Ewart A. Everson, A. John Grover, Leslie Silburn Hazell, Gordon E. Heaton, Roy Victor Jeffery, Robert W. Kolb, Paul L'Heureux, Douglas Hulse Moore, Gordon M. Pfeiffer, Gerard Plourde, Russell Watson, Dennis Alfred West.

Chicago Section

Eugene Anton Bruha, Howard Eberhardt, Ernest Albert Ferris, E. D. Kruger, Arville R. Ousdahl, Bernard J. Toale.

Cleveland Section

Edward G. Belden, Ralph K. Boyer, Pitt A. Curtiss.

Detroit Section

Frank M. Belyan, Robert H. Bollinger, Earl E. Borseth, Robert W. Carbary, Frank Anthony Cillette, Richard L. Dahlgren, John W. Drake, R. Boyd Jones, Robert C. Leary, Ralph R. Lord, Nelson G. Meagley, Foster H. Middleton, William Thomas Morden, James G. Morrison, George James Nutil, John Joseph Olis, Charles H. Phaneuf, Rex E. Phelps, John Edward Quirk, John Mueller Reinhart, Hubert W. Stephens, Charles L. Waterhouse, Jr.

Hawaii Section

Ed M. Hayashi, John O. Spengler.

Indiana Section

William C. Edmundson, William A. Fletcher, Herman Staggenburg.

Kansas City Section

Stuart L. Spradling.

Metropolitan Section

Vincent D'Aversa, Robert Meyric Ellis, Ernst Halpern, Richard Caldwater Kerr, Fred J. Lucente, Thomas H. McConnell, Jr., Henry G. Mushmore, Eugene Donald O'Reilly, Charles T. Stone.

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Merrill William Jensen, Joseph V. Reichenbach, Theodore J. Schweitzer,

Norbert M. Vogl.

Northern California Section

Charles E. Bull, Louis M. Corbell, Robert C. Jones, Neilson Jackson Reese.

Northwest Section

Bob Bade.

Oregon Section

Howard Vernon Hinckley.

Philadelphia Section

Robert William Graham, Charles S. Schaevitz, A. R. Vickers.

Southern California Section

Chester A. Elliott, Alfred Goldberg, K. V. Hackman, James Kimball Lingenfelter, Paul M. Moore, True R. Slocum, Jr., Abe J. Victor, Donald H. Westermeier.

Southern New England Section

David Edson Breed, John F. Burridge, Louis Fontanella, Robert Francis Naczi, Edmond Louis Patton, Jr.

Spokane-Intermountain Section

P. L. Polizzotto.

Syracuse Section

Richard B. Clark.

Texas Section

H. L. McMullin, S. E. Murphree, Thomas H. Pofahl.

Virginia Section

William E. Bristow, Alfred Pemberton.

Washington Section

Charles L. Arnold, Arthur Richards Smith.

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John David Calhoun, Jr., Collins L. Carter, Capt. Luther Wesley Feagin, Marshall C. Gillispie, Anicut Parthasarathy Jambulingam, Malcolm G. Maginnis, Harold V. Messick, John M. Olson, Everett A. Pruess, Harvey W. Rockwell, Frederick J. Sanborn, William Carl Voight, Jr., John Waldherr, Jr.

Foreign

Maurice E. Barthalon, France; Thomas Henry Innes, New Zealand; John Parkinson, England; Stanley Charles Toll, South Africa; John Desmond Wilcox, England; Cecil John Williams, England.

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Dayton

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(Mrs.) S. J. Duvall, Detroit Office, SAE, 100 Farnsworth Ave., Detroit 2, Mich.

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Fred Hedemann, 2110 A Kakela Pl., Honolulu, T.H.

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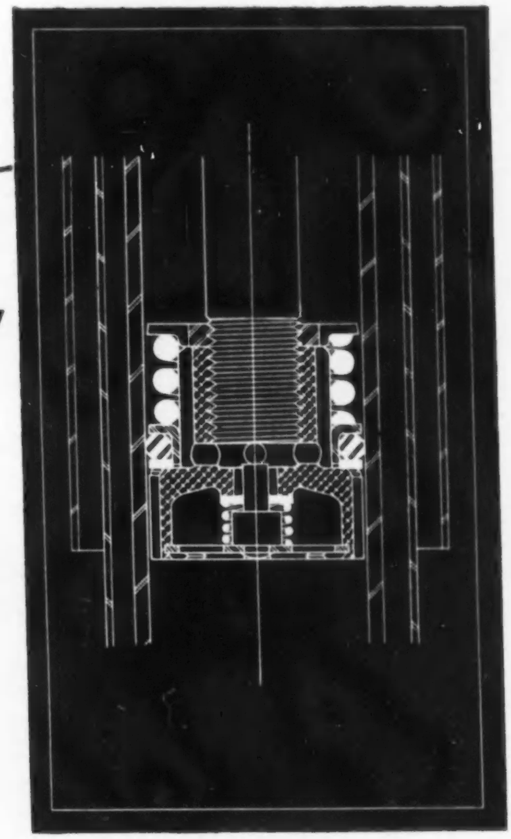

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Charles L. Fernau, Standard Oil Co. of Calif., 605 W. Olympic Blvd., Los Angeles 15, Calif.

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Peter J. Favre, 10 W. Third Ave., Spokane 8, Wash.

Syracuse

Leslie R. Parkinson, 117 Harrington Rd., Syracuse, N. Y.

Texas

Ross A. Peterson, Texas Trade School, 1316 W. Commerce St., Dallas 8, Tex.

Twin City

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Robert P. Knighton, Esso Standard Oil Co., Broad & Hamilton Sts., Richmond 21, Va.

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Hyman Feldman, 3222 M St., N.W., Washington, D. C.

Western Michigan

Thomas Reeves, Continental Motors Corp., Muskegon, Mich.

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